U.S. Department of the Interior

Rainfall, Streamflow, and Water-Quality Data During Stormwater Monitoring, Halawa Stream Drainage Basin, Oahu, Hawaii, July 1, 2001 to June 30, 2002

U.S. GEOLOGICAL SURVEY

Open-File Report 02-319

Prepared in cooperation with the

STATE OF HAWAII DEPARTMENT OF TRANSPORTATION

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By Todd K. Presley

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Honolulu, Hawaii
2002

U.S. DEPARTMENT OF THE INTERIOR

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U.S. GEOLOGICAL SURVEY

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Rainfall, Streamflow, and Water-Quality Data During Stormwater Monitoring, Halawa Stream Drainage Basin, Oahu, Hawaii, July 1, 2001 to June 30, 2002

By Todd K. Presley

Abstract

The State of Hawaii Department of Transportation Stormwater Monitoring Program was implemented on January 1, 2001. The program includes the collection of rainfall, streamflow, and water-quality data at selected sites in the Halawa Stream drainage basin. Rainfall data were collected at two sites, and streamflow data were collected at 3 sites for the year July 1, 2001 to June 30, 2002. Water-quality data were collected at five sites, which include the three streamflow sites.

Six storms were sampled during the year July 1, 2001 to June 30, 2002, for a total of 44 samples. For each storm event, grab samples were collected nearly simultaneously at all five sites, and flow-weighted, time-composite samples were collected at the three sites equipped with automatic samplers. Samples were analyzed for nutrients, trace metals, oil and grease, total petroleum hydrocarbons, fecal coliform, biological oxygen demand, chemical oxygen demand, total suspended solids, and total dissolved solids. Quality assurance samples were also collected to verify analytical procedures and insure proper cleaning of equipment.

INTRODUCTION

The State of Hawaii Department of Transportation (DOT) Stormwater Monitoring Program Plan (State of Hawaii Department of Transportation, 2000) was implemented on January 1, 2001, to monitor the Halawa Stream drainage basin, Oahu, Hawaii (fig. 1). The Stormwater Monitoring Program Plan was designed to fulfill permit requirements for the National Pollutant Discharge Elimination System (NPDES) program. The Stormwater Monitoring Program Plan includes the collection of rainfall, streamflow, and water-quality data at selected sites in the Halawa Stream drainage basin.

This report summarizes stormwater-monitoring activities and water-quality data collected by the U.S. Geological Survey (USGS) as part of the Stormwater Monitoring Program Plan. This report presents rainfall, streamflow, and water-quality data collected from July 1, 2001 to June 30, 2002. Descriptions of the sampling techniques are included with the water-quality data.

Six storms were sampled during July 1, 2001 to June 30, 2002, for a total of 44 samples. In addition to these samples, 22 quality-assurance/quality-control (qa/qc) samples were collected: 12 samples were collected concurrently with storm samples during four of the storms, and 10 samples were collected between storms during routine cleaning of the sampling equipment. Water-quality data for the qa/qc samples are not published in this report but are available upon request.

DATA-COLLECTION NETWORK

Stream-stage, stream-discharge, rainfall, and water-quality data were collected at selected sites in the Halawa Stream drainage basin (fig. 1). Rainfall data were collected at two sites, the North Halawa Valley Rain Gage at tunnel (abbreviated to Tunnel rain gage, 212428157511201) and the North Halawa Rain Gage near Honolulu (abbreviated to Xeriscape garden rain gage, 212304157542201). Streamflow data were

collected at three sites within North Halawa Valley. Streamflow data has been collected at Storm drain C (212353157533001) and at North Halawa Stream near Honolulu streamflow-gaging station (abbreviated to Xeriscape garden, 16226200) since 1998 and 1983, respectively. A new gage site, located near the State of Hawaii Animal Quarantine Station, (abbreviated to Quarantine station, 16226400) began data collection on October 27, 2001. Rainfall and streamflow data are collected using variable time-steps depending on rainfall or streamflow rates. The data from the two rain gages and the three streamflow-gaging stations are transferred daily to the USGS database using cellular-phone telemetry.

Water-quality data were collected at five sites (fig. 1): North Halawa Stream at Bridge 8 near Halawa (abbreviated to Bridge 8, 212356157531801), Storm drain C, Xeriscape garden, Quarantine station, and Halawa Stream below H-1 (abbreviated to Stadium, 16227100). The Bridge 8 site is located above the discharge point of Storm drain C on North Halawa Stream. Storm drain C collects runoff from an approximately 4-mile section of freeway, up-valley to the tunnel portal at the Koolau Crest. The Xeriscape garden gage is directly upstream from a light-industrial area on North Halawa Stream, but downstream of the discharge point of Storm drain C. The Quarantine station site is also on North Halawa Stream, and is within the light-industrial area. The Stadium site is below the confluence of North and South Halawa Streams, downstream from the crossing of H-1 freeway, and directly upstream from the mouth of Pearl Harbor.

WATER-QUALITY SAMPLING TECHNIQUES

Water-quality samples were collected at least once per quarter from the five sites (fig. 1). The first storm of each quarter was sampled. Water-quality samples included both grab samples and flow-weighted, time-composite samples.

Storm criteria.--The U.S. Environmental Protection Agency's (USEPA) Storm Water Sampling Guidance Manual (U.S. Environmental Protection Agency, Office of Water, 1993) provides guidance on criteria for sampling runoff. One criteria requires that sampling only be performed on storms preceded by at least 72 hours of dry weather. In practice, this criteria could prevent sampling of many storms on North Halawa Stream.

Sample collection.--In general, grab samples were collected manually using isokinetic, depth-integrating samplers and equal-width increment (EWI) sampling techniques (Wilde and others, 1998). The sampler collects water in an isokinetic manner, in which water enters the sampler at the same velocity as the stream flow. The sampler is made of high-density polyethylene (HDPE). The EWI sampling technique, in which evenly-spaced sampling points along the cross section of the stream are proportionately sampled based on the discharge of each increment, was used where suitable or practical. During the high-discharge events that were sampled, however, the stream was well mixed at each site, such that the EWI method was not necessary. At such times, the centroid of flow of the stream was estimated, and a single vertical section was sampled with the isokinetic sampler. Each sub-sample from the EWI technique or from the single-vertical technique was composited in an HDPE churn.

Time-composite samples were collected over a time period that sometimes lasted several hours using an automatic sampler. Automatic samplers collect water from a fixed point in the stream channel after pre-determined stage thresholds are met. The automatic samplers have a capacity of 24 bottles. When the first threshold was met, the automatic samplers were programmed to sample water every minute for the first five samples, and then every 15 minutes. When a higher, second threshold was met, the automatic samplers were programmed to sample water every 7 minutes.

The first five samples, collected on 1-minute intervals, can be combined and used as a grab sample in the situation in which grab samples cannot be collected manually. This technique is not ideal for many of the analyses. The first three of these samples are collected in bottles lined with teflon bags, primarily for oil and grease and total petroleum hydrocarbon analyses. Residues that contain oil and grease and total petroleum hydrocarbons tend to stick to surfaces, potentially changing the concentration of the constituents when transferring from container to container. Additionally, some constituents require the sample to be chilled prior to analyses, and require analyses soon after collection. The automatic samplers are not equipped with refrigeration units, and holding times for these analyses may be exceeded.

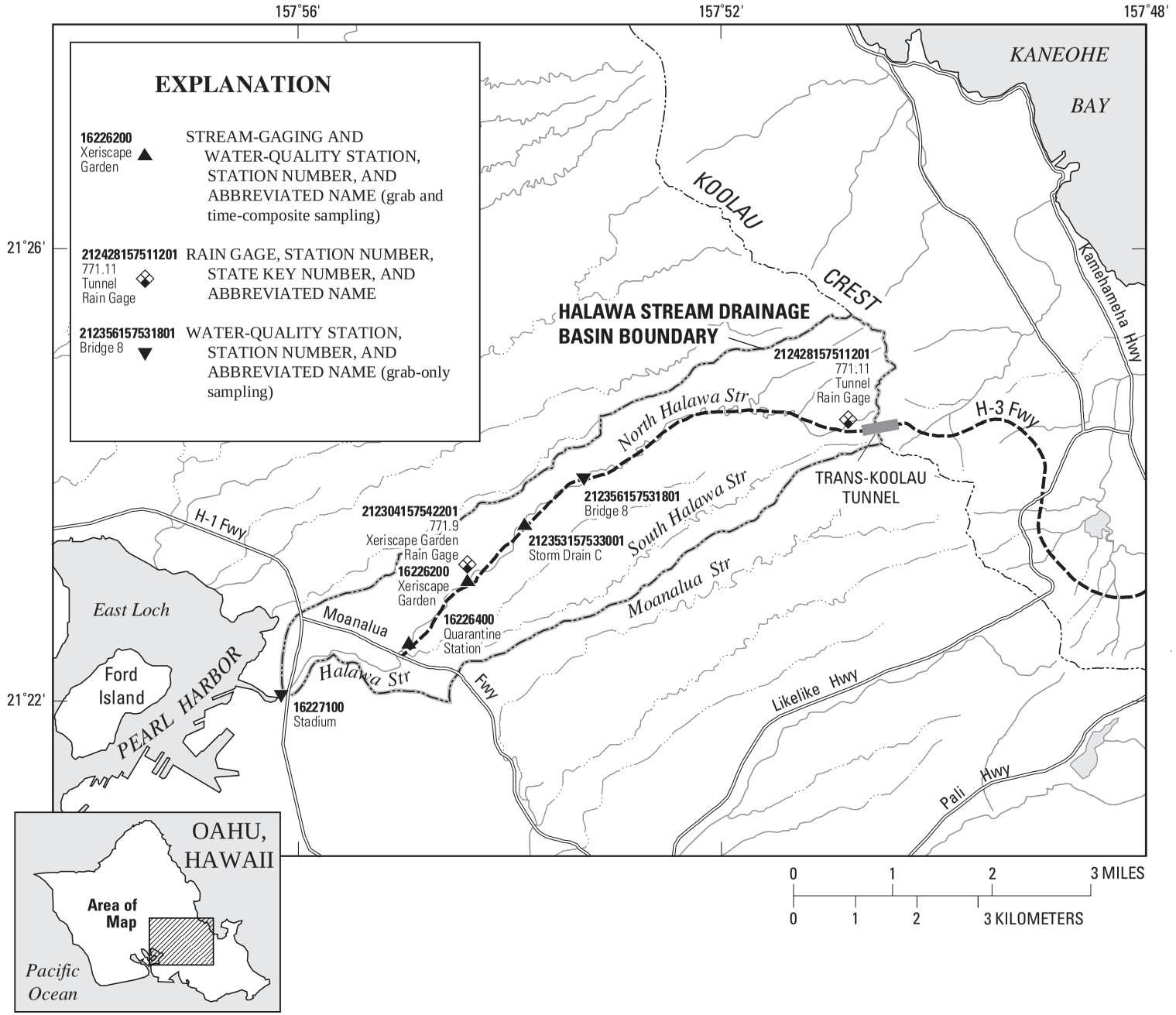

Figure 1. Streamflow-gaging stations, rain gages, and water-quality sampling sites in the Halawa Stream drainage basin, Oahu, Hawaii.

A flow-weighted, time-composite sample was created by combining, in a clean HDPE churn, all or part of the samples collected by the automatic sampler. The desired volume of water from each sample is proportional to the stream discharge volume between samples.

Of the five water-quality sites, only Storm drain C, Xeriscape garden, and Quarantine station streamflow-gaging stations are equipped with automatic samplers. The automatic sampler at the Quarantine station site was operational since December 17, 2001.

Determination of discharge.--At the Bridge 8, Storm drain C, Xeriscape garden, and Quarantine station sites, discharge associated with each sample was determined using a stage-discharge relation (streamflow rating) created for the sampled site, or by measurement using a current meter. Streamflow ratings were developed by measurements and computer modeling, and verified by subsequent measurements. At the Stadium site, the wide and curving concrete channel and shallow and swift streamflow precluded the development of an accurate streamflow rating. Discharge at this site was measured using a current meter, or at higher flows, using float-measurement techniques in which floating bottles were timed over a known distance to determine velocity, and the area of the cross-section was estimated by the depth of water and surveyed dimensions of the channel.

An average-discharge value was calculated for each composite sample. The average-discharge value was equal to the total volume of water that passed by the gaging station during sample collection, divided by the total elapsed time during sample collection, for only the samples used for the composite. To determine the total volume, the discharge at the time of sample collection was multiplied by the elapsed time between each sample collected. The same time increment between the first and second samples was assigned to the first sample. These volumes were summed, and the total volume was divided by the sum of all the time increments. This method overestimates average discharge if the stream discharge was increasing during sample collection, and underestimates average discharge if the stream discharge was decreasing.

Sample processing, analysis, and quality-assurance/quality-control.--USGS water-quality methods (Wilde and others, 1998) were followed to prevent possible contamination during sample processing. Both grab and composite samples were processed using churns to mix and suspend sediment while delivering the sample to specific bottles for the various constituent analyses.

As required by the Stormwater Sampling Program Plan, samples were analyzed for temperature, pH, specific conductance, nutrients, trace metals, oil and grease, total petroleum hydrocarbons, fecal coliform, biological oxygen demand, chemical oxygen demand, total suspended solids, and total dissolved solids. Field measurements of temperature, pH, and specific conductance were made by USGS personnel. Fecal coliform and biological oxygen demand analyses were performed by Aecos Incorporated, a private laboratory on Oahu. All other analyses were performed at the USGS National Water Quality Laboratory (NWQL), in Denver, Colorado.

Three quality-control/quality-assurance (qa/qc) samples were collected at different sites during each storm: a field duplicate (sample was split into two during sample processing), a laboratory duplicate (sample was analyzed twice at the laboratory), and a spiked sample, (part of the sample was spiked in the laboratory with a known quantity of analyte).

During the interim between storms, non-dedicated and non-disposable equipment, such as churns, isokinetic samplers, automatic sampler intake lines, and teflon automatic sampler bottle liners, were cleaned and tested for contamination. Inorganic blank water, free of inorganic constituents, was passed through this equipment and re-collected as a rinsate sample. The rinsate sample was analyzed for the same inorganic constituents as the storm samples.

RAINFALL AND STREAMFLOW DATA

Hydrographs of daily rainfall and daily mean streamflow data for the period July 1, 2001 through June 30, 2002 are shown in figure 2. The highest daily rainfall at the Tunnel rain gage was 10.1 inches (in.) on May 6, 2002. Daily rainfall values greater than 3.9 in. occurred on September 16, 2001, January 26, 27, and 28, 2002, and February 4, 2002. The highest daily rainfall at the Xeriscape garden rain gage was 4.5 in. on January 26, 2002. Daily rainfall values greater than 1.7 in. occurred on September 16, October 27, November 27 in 2001, and January 24 and May 7, in 2002.

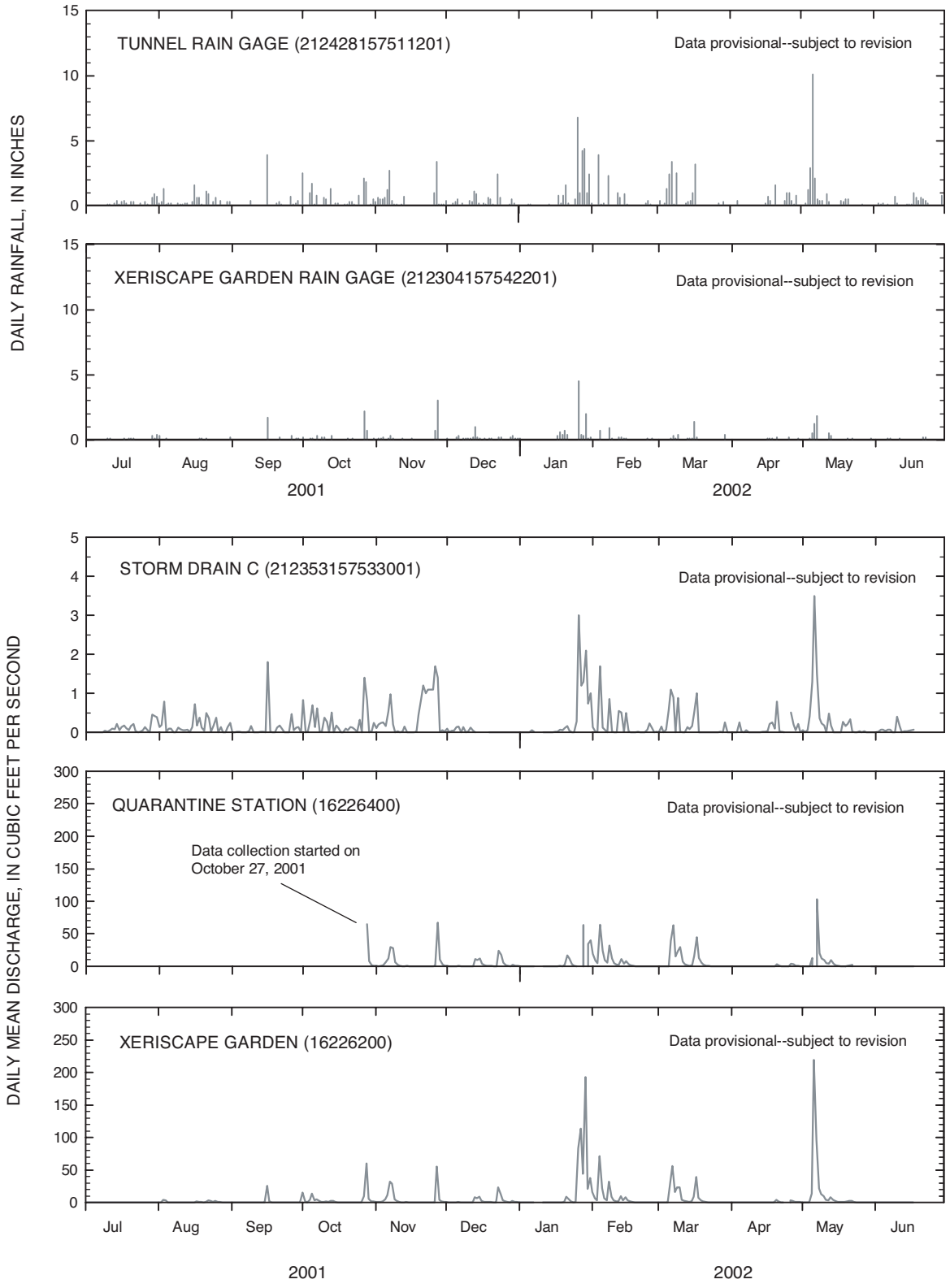

Figure 2. Rainfall and stream discharge for stations in the Halawa Stream drainage basin, Oahu, Hawaii, for July 1, 2001 to June 30, 2002.

For Storm drain C, the highest daily mean discharge, 3.5 cubic feet per second (ft^3/s), occurred on May 6, 2002. Daily mean discharge values greater than 1.8 ft^3/s were recorded on three other days within the 12-month period; September 16, 2001, January 26 and 29, 2002. At Xeriscape garden streamflow-gaging station, the highest daily mean discharge was 226 ft^3/s on May 6, 2002. Daily mean discharge values of 74 ft^3/s or greater were recorded on January 26, 27, and 29, and May 7, 2002. At the Quarantine station gaging station, the highest daily mean discharge was 103 ft^3/s on May 7, 2002. Daily mean discharge values of 65 ft^3/s or greater were recorded on October 28 and November 27, 2001.

STORMWATER SAMPLING: CONDITIONS AND RESULTS

During the period July 1, 2001 through June 30, 2002, at least 10 storms created enough runoff and stream discharge for sampling. Of these storms, 6 were sampled: September 16, 2001, October 27–28, 2001, January 26–27, 2002, January 28–29, 2002, April 20, 2002, and May 5–6, 2002.

Storm of September 16, 2001

Hydrologic Conditions During Sampling and Data Collection

Hydrographs of streamflow at Storm drain C and Xeriscape garden during the storm of September 16, 2001 are shown in figures 3 and 4, respectively. The times of peak flow, and the times of grab-sample collection and corresponding discharges at the times of sample collection, are listed in table 1. The number of samples collected by the automatic samplers and used for the composite samples, the beginning and end times of sample collection by the automatic samplers, and the average discharges during the collection of the composite samples are shown in table 2. Sample-collection times also are displayed in the hydrographs (figs. 3 and 4).

Sampling and Discharge Measurement Methods

Five grab samples were collected at five sites during the storm on September 16, 2001. Two composite samples were collected at Storm drain C and Xeriscape garden sites. Fecal coliform and biological oxygen demand samples were not collected at any of the sites for this storm. The storm sampling occurred in the afternoon on a Sunday, and prior arrangements could not be made for these analyses.

Bridge 8.-- The grab sample was collected using the EWI method at five evenly distributed sampling points along the cross section of the stream. Stream width was about 26 ft. An isokinetic sampler was used to collect the sample. Discharge was concentrated in the middle 6 ft of the stream cross section. A field duplicate sample was collected at this site. Discharge was measured using a current meter immediately after the sample was collected.

Storm drain C.--At the time of the collection of the grab sample, which was almost 8 hours after the discharge peak, the stage at the storm drain was only about 0.02 ft above the point of zero flow (fig. 3). Discharge was about 0.02 ft^3/s. The grab sample was collected at the centroid of flow by directly submersing a churn into the flow. Temperature and specific-conductance were not measured at this site. Discharge associated with the grab sample was determined using the stage at the time of sample collection and the stage-discharge rating for this gage.

A time-composite sample was created using 11 samples from the automatic sampler. The composite sample was not flow weighted; the entire volumes of all 11 samples were poured into the churn.

Xeriscape garden.--The grab sample was collected using the EWI method at 10 sampling points distributed about every 2 ft along the cross section of the stream. Stream width was about 22 ft. An isokinetic sampler was used to collect the sample. Water from this site also was used for a laboratory spike sample. Discharge associated with the grab sample was determined using the stage at the mean time of sample collection and the stage-discharge rating for this gage.

A time-composite sample was created using 8 samples from the automatic sampler. The composite sample was not flow weighted; the entire volumes of all 8 samples were poured into the churn.

Quarantine station.--The grab sample was collected using the EWI method at 9 sampling points along the cross section of the stream. Stream width was about 20 ft. An isokinetic sampler was used to collect the sample. Sample water from this site also was used for a lab-

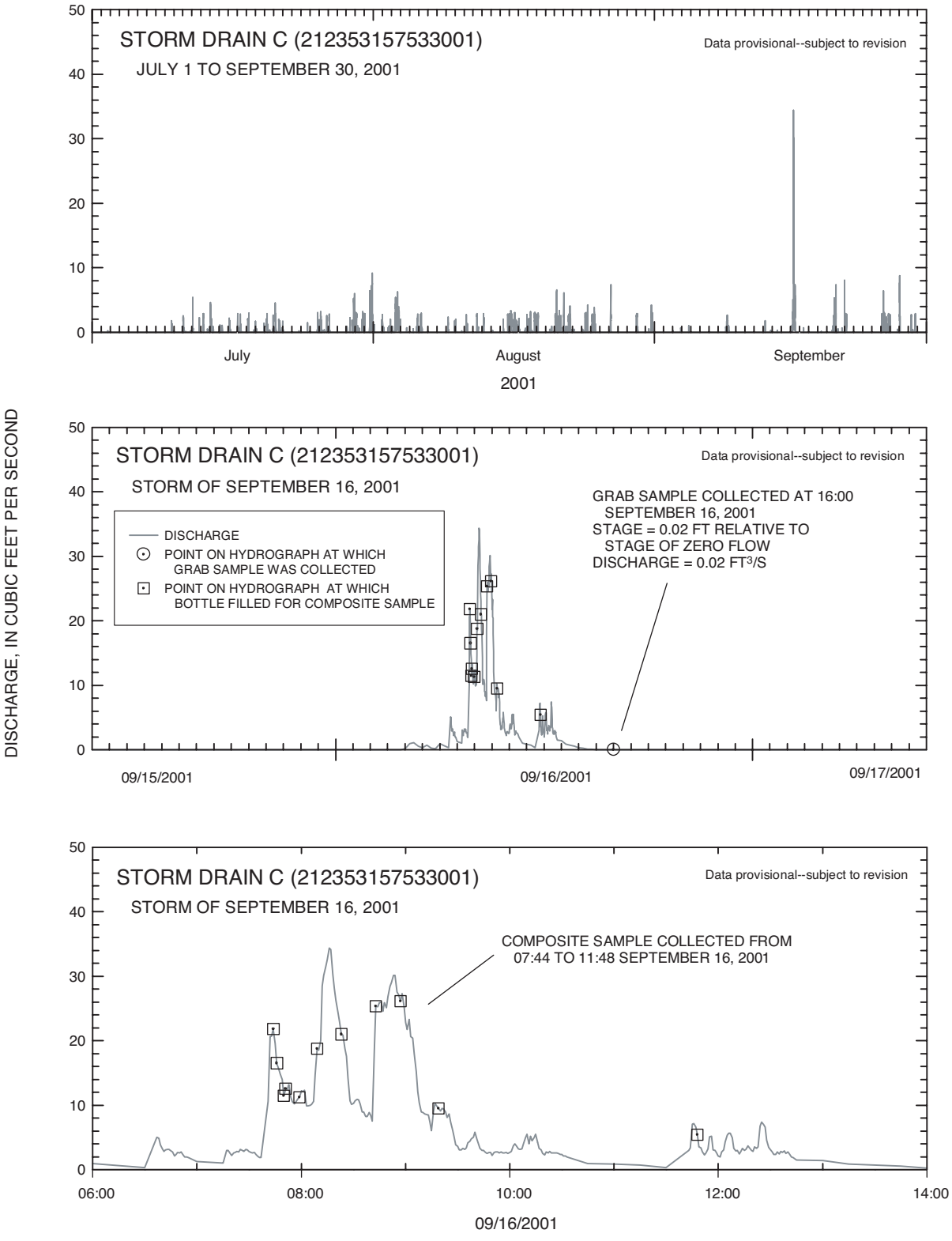

Figure 3. Stream discharge at Storm drain C gaging station (212353157533001) for July 1 to September 30, 2001; detail for the 2-day period from 10:00 September 15, 2001 to 10:00 September 17, 2001; and detail for the 8-hour period from 06:00 to 14:00, September 16, 2001, Oahu, Hawaii.

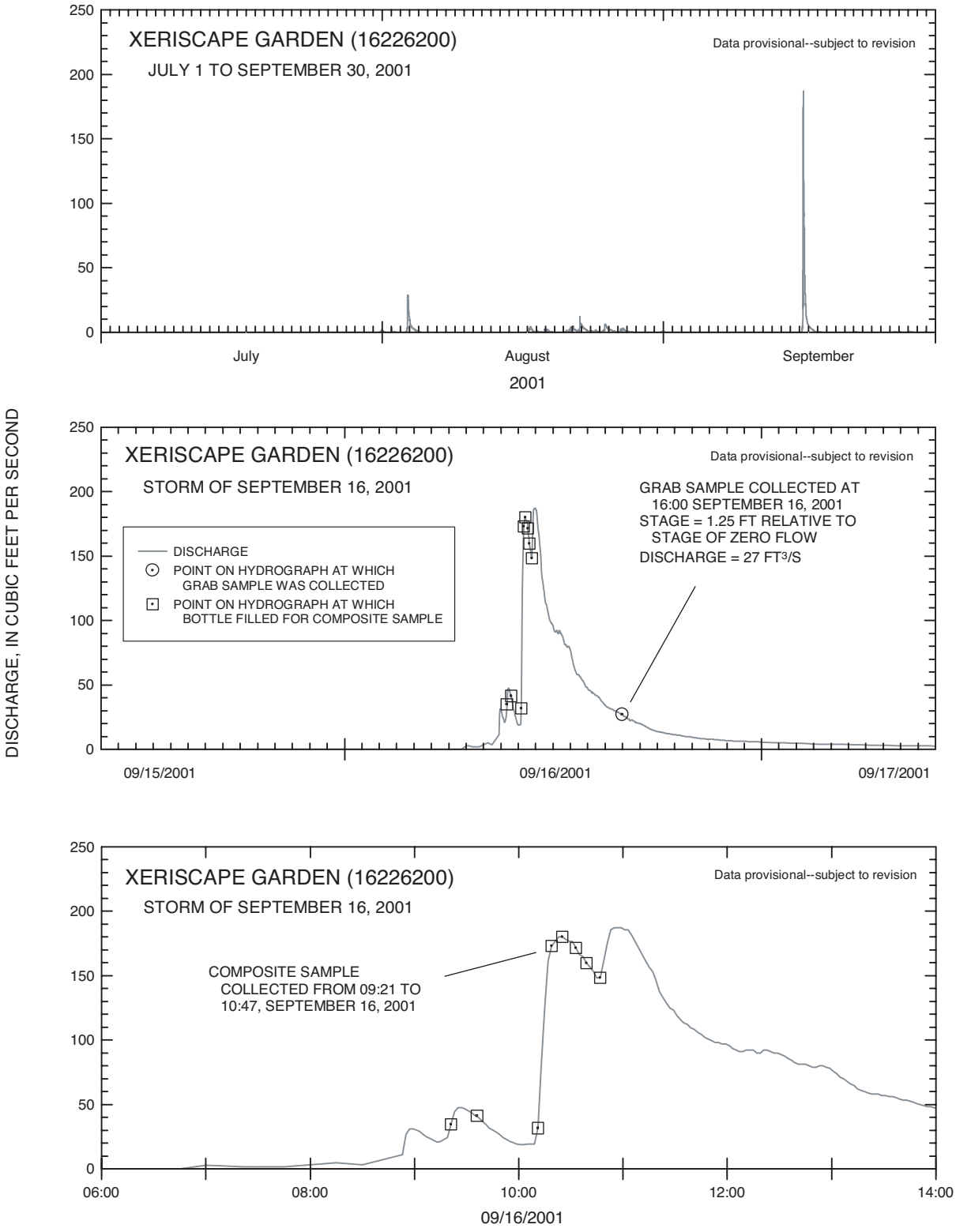

Figure 4. Stream discharge at Xeriscape garden gaging station (16226200) for July 1 to September 30, 2001; detail for the 2-day period from 10:00 September 15, 2001 to 10:00 September 17, 2001; and detail for the 8-hour period from 06:00 to 14:00, September 16, 2001, Oahu, Hawaii.

Table 1. Hydrologic conditions during grab-sample collection, September 16, 2001, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision
[--, no data; ft^3/s, cubic feet per second]

Abbreviated station name and station number	Date and time of peak discharge	Peak stage (feet over stage of zero flow)	Peak discharge (ft^3/s)	Date and time of grab- sample collection	Stage at time of grab- sample collection, (feet above stage of zero flow)	Discharge at time of grab-sample collection, (ft^3/s)
Bridge 8 (212356157531801)	--	--	--	09/16/2001 13:30	--	30
Storm drain C (212353157533001)	09/16/2001 08:17	3.22	34	09/16/2001 16:00	0.02	0.02
Xeriscape garden (16226200)	09/16/2001 10:55	2.70	187	09/16/2001 16:00	1.25	27
Quarantine station (16226400)	--	--	--	09/16/2001 15:00	1.55	33
Stadium (16227100)	--	--	--	09/16/2001 13:15	--	88

Table 2. Hydrologic conditions and sampling data during composite-sample collection, September 16, 2001, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision
[ft^3/s, cubic feet per second]

Abbreviated station name and station number	Date and time of peak discharge	Peak discharge (ft^3/s)	Beginning and ending dates and times of automatic-sample collection	Number of samples used for composite sample	Range of discharge at times of sample collection (ft^3/s)	Average discharge during sample collection (ft^3/s)	Compositing technique and notes
Storm drain C (212353157533001)	09/16/2001 08:17	34	09/16/2001 07:44 to 09/16/2001 11:48	11	5.4 –26	10	not flow weighted
Xeriscape garden (16226200)	09/16/2001 10:55	187	09/16/2001 09:21 to 09/16/2001 10:47	8	32 – 180	80	not flow weighted

oratory duplicate sample. Discharge was determined using the stage at the mean time of sample collection and the stage-discharge rating for this gage.

Stadium.--A grab sample was collected at 9 intervals spaced 4 to 6 ft apart, using a HDPE 1-liter open-mouth bottle because of the shallow depths and swift-moving water. Stream width was about 64 ft. A discharge measurement was made using a current meter. Stage relative to a measuring point on the bridge was not measured during this sampling.

Analytical Results and Loads

The samples were analyzed for all of the constituents listed in the Stormwater Monitoring Program Plan (State of Hawaii Department of Transportation, 2000), except for fecal coliform and biological oxygen demand. Temperature, pH, and specific-conductance values from field measurements are shown in table 3. Constituent concentrations and instantaneous loads for the five grab samples are shown in table 4, constituent concentrations and average loads for the two composite samples are shown in table 5.

Table 3. Temperature, pH, and specific-conductance field measurements for grab samples collected on September 16, 2001, Halawa Stream drainage basin, Oahu, Hawaii

Data provisional--subject to revision

[°C, degrees Celsius; µS/cm, microsiemens per centimeter]

Physical property	Unit	Reporting level	Abbreviated station name and number				
			Bridge 8 (212356157531801)	Storm drain C (212353157533001)	Xeriscape garden (16226200)	Quarantine station (16226400)	Stadium (16227100)
Temperature	°C	nearest 0.5°C	23.0	no measurement	23.5	23.0	25.5
pH	pH	nearest 0.1	7.4	7.8	7.1	7.4	7.4
Specific conductance	µS/cm	nearest whole number	97	no measurement	99	102	87

Table 4. Concentrations and instantaneous loads of physical properties and constituents for grab samples collected from Halawa Stream drainage basin on September 16, 2001, Oahu, Hawaii.

Data provisional--subject to revision.

[Conc., concentration; Instant. load, instantaneous load; na, not applicable; <, actual value is less than value shown; ≤, actual value less than or equal to value shown; e, estimated value; mg/L, milligrams per liter; µg/L, micrograms per liter; loads reported as lbs/day, pounds per day]

Physical property or constituent	Concentration unit	Instantaneous load unit	Minimum reporting level for concentration[a]	Abbreviated station name and number									
				Bridge 8 (212356157531801)		Storm drain C (212353157533001)		Xeriscape garden (16226200)		Quarantine station (16226400)		Stadium (16227100)	
				Conc.	Instant. load[f]	Conc.	Instant. load[f]	Conc.	Instant. load[f]	Conc.	Instant. load[f]	Conc.	Instant. load[f]
Chemical oxygen demand	mg/L	lbs/day	10	17	2,800	<10	<1	13	1,900	<10	<1,800	40	19,000
Total suspended solids	mg/L	lbs/day	10	32	5,200	<10	<1	10	1,500	43	7,700	155	74,000
Total dissolved solids	mg/L	lbs/day	10	60	9,700	132	10	72	10,000	76	14,000	64	30,000
Nitrogen, total organic + ammonia[b]	mg/L	lbs/day	0.10	0.51	83	0.12	0.01	0.33	48	0.51	91	1.4	660
Ammonia, dissolved, as N[c]	mg/L	lbs/day	0.040	<0.040	<6.5	<0.040	<0.004	<0.040	<5.8	<0.040	<7.1	<0.040	<19
Nitrogen, nitrite, dissolved, as N[c]	mg/L	lbs/day	0.006	<0.006	<1	<0.006	<0.0006	<0.006	<0.9	<0.006	<1	0.009	4
Nitrate + nitrite, dissolved, as N[c]	mg/L	lbs/day	0.050	0.085	14	0.582	0.06	0.105	15	0.158	28	0.179	85
Total nitrogen, as N[d]	mg/L	lbs/day	na	0.60	97	0.70	0.08	0.44	64	0.67	120	1.6	760
Organic nitrogen, as N[e]	mg/L	lbs/day	na	≤0.51	≤83	≤0.12	≤0.01	≤0.33	≤48	≤0.51	≤91	≤1.4	≤660
Total phosphorus, as P	mg/L	lbs/day	0.060	0.090	15	0.093	0.01	e0.046	e6.7	0.093	17	0.341	160
Dissolved phosphorous, as P	mg/L	lbs/day	0.060	<0.060	<9.7	0.080	0.009	<0.060	<8.7	<0.060	<11	e0.042	e20
Total cadmium	µg/L	lbs/day	0.04	e0.02	e0.003	e0.02	e0.000002	e0.02	e0.003	e0.03	e0.005	0.12	0.057
Total copper	µg/L	lbs/day	0.6	4.5	0.73	4.6	0.0005	3.8	0.55	6.2	1.1	20.1	9.5
Total lead	µg/L	lbs/day	1	<1	<0.2	<1	<0.0001	<1	<0.1	1	0.2	7	3
Total zinc	µg/L	lbs/day	1	5	0.8	8	0.0009	4	0.6	11	2.0	50	24
Oil and grease	mg/L	lbs/day	1	<1	200	1	0.1	<1	<100	<1	<200	<1	<500
Total petroleum hydrocarbons	mg/L	lbs/day	2	<2	300	<2	<0.2	<2	<300	<2	<400	<2	<900

[a] Minimum reporting levels are based on values published by the USGS National Water Quality Laboratory.

[b] Nitrogen, total organic + ammonia is total Kjeldahl nitrogen.

[c] Ammonia, nitrite, and nitrate + nitrite are analyzed from filtrate. In January 1993, USGS National Water Quality Laboratory analyses for total ammonia, total nitrite, and total nitrate + nitrite were discontinued and only dissolved ammonia, dissolved nitrite, and dissolved nitrate + nitrite were analyzed after that date. Values for the total and for the dissolved constituents were statistically indistinguishable (U.S. Geological Survey Office of Water Quality Technical Memorandum 93.04). USGS National Water Quality Laboratory methods for these constituents are different from USEPA methods; however, USGS methods have similar or more accurate results.

[d] Total nitrogen is calculated by adding nitrogen, total organic + ammonia (Kjeldahl) to nitrate + nitrite, dissolved.

[e] Organic nitrogen is calculated by subtracting ammonia, dissolved, from nitrogen, total organic and ammonia (Kjeldahl). If the concentration value of ammonia, dissolved is below the minimum reporting level, the concentration value for organic nitrogen is reported as less than or equal to the value of total organic and ammonia (Kjeldahl), which represents the maximum possible value for organic nitrogen.

[f] Instantaneous loads are computed from the concentration of grab sample and the discharge at the mean time of sample collection.

Table 5. Concentrations and average loads of physical properties and constituents for composite samples collected from Halawa Stream drainage basin on September 16, 2001, Oahu, Hawaii.

Data provisional--subject to revision.

[Conc., concentration; na, not applicable; <, actual value is less than value shown; ≤, actual value less than or equal to value shown; e, estimated value; mg/L, milligrams per liter; µg/L, micrograms per liter; loads reported as lbs/day, pounds per day]

Physical property or constituent	Concentration unit	Composite sample average load unit	Minimum reporting level for concentration[a]	Abbreviated station name and number: Storm drain C (212353157533001)		Xeriscape garden (16226200)	
				Conc.	Average load[f]	Conc.	Average load[f]
Chemical oxygen demand	mg/L	lbs/day	10	21	1,100	110	47,000
Total suspended solids	mg/L	lbs/day	10	47	2,500	522	23,000
Total dissolved solids	mg/L	lbs/day	10	22	1,200	46	20,000
Nitrogen, total organic + ammonia[b]	mg/L	lbs/day	0.10	0.86	46	2.2	950
Ammonia, dissolved, as N[c]	mg/L	lbs/day	0.040	e0.032	e1.7	<0.040	<17
Nitrogen, nitrite, dissolved, as N[c]	mg/L	lbs/day	0.006	<0.006	<0.3	<0.006	<3
Nitrate + nitrite, dissolved, as N[c]	mg/L	lbs/day	0.050	0.053	2.9	0.104	45
Total nitrogen, as N[d]	mg/L	lbs/day	na	0.91	49	2.3	990
Organic nitrogen, as N[e]	mg/L	lbs/day	na	e0.83	e45	≤2.2	≤950
Total phosphorus, as P	mg/L	lbs/day	0.060	0.188	10	0.582	250
Dissolved phosphorous, as P	mg/L	lbs/day	0.060	<0.060	<3.2	<0.060	<26
Total cadmium	µg/L	lbs/day	0.04	0.30	0.016	0.35	0.15
Total copper	µg/L	lbs/day	0.6	136	7.3	64.0	28
Total lead	µg/L	lbs/day	1	12	0.65	11	4.7
Total zinc	µg/L	lbs/day	1	142	7.7	128	55

[a] Minimum reporting levels are based on values published by the USGS National Water Quality Laboratory.

[b] Nitrogen, total organic + ammonia is total Kjeldahl nitrogen.

[c] Ammonia, nitrite, and nitrate + nitrite are analyzed from filtrate. In January 1993, USGS National Water Quality Laboratory analyses for total ammonia, total nitrite, and total nitrate + nitrite were discontinued and only dissolved ammonia, dissolved nitrite, and dissolved nitrate + nitrite were analyzed after that date. Values for the total and for the dissolved constituents were statistically indistinguishable (U.S. Geological Survey Office of Water Quality Technical Memorandum 93.04). USGS National Water Quality Laboratory methods for these constituents are different from USEPA methods; however, USGS methods have similar or more accurate results.

[d] Total nitrogen is calculated by adding nitrogen, total organic and ammonia (Kjeldahl) to nitrate + nitrite, dissolved.

[e] Organic nitrogen is calculated by subtracting ammonia, dissolved, from nitrogen, total organic and ammonia (Kjeldahl). If the concentration value of ammonia, dissolved is below the minimum reporting level, the concentration value for organic nitrogen is reported as less than or equal to the value of total organic and ammonia (Kjeldahl), which represents the maximum possible value for organic nitrogen.

[f] Average loads are computed from the concentration of composite sample and the average discharge during sample collection.

Storm of October 27–28, 2001

Hydrologic Conditions During Sampling and Data Collection

Hydrographs of streamflow at Storm drain C, Xeriscape garden and Quarantine station during the storm of October 27–28, 2001 are shown in figures 5, 6 and 7, respectively. The times of peak flow, and the times of grab-sample collection and corresponding discharges at the times of sample collection, are listed in table 6. The number of samples collected by the automatic samplers and used for the composite samples, the beginning and end times of sample collection by the automatic samplers, and the average discharges during the collection of the composite samples are shown in table 7. Sample-collection times also are displayed in the hydrographs (figs. 5, 6, and 7).

Sampling and Discharge Measurement Methods

Grab samples were collected at all sites except for Storm drain C during the storm on October 27–28, 2001. Composite samples were collected at the Storm drain C and Xeriscape garden sites.

Bridge 8.-- The grab sample was collected using the EWI method at 10 sampling points spaced every 2 ft along the cross section of the stream. Stream width was

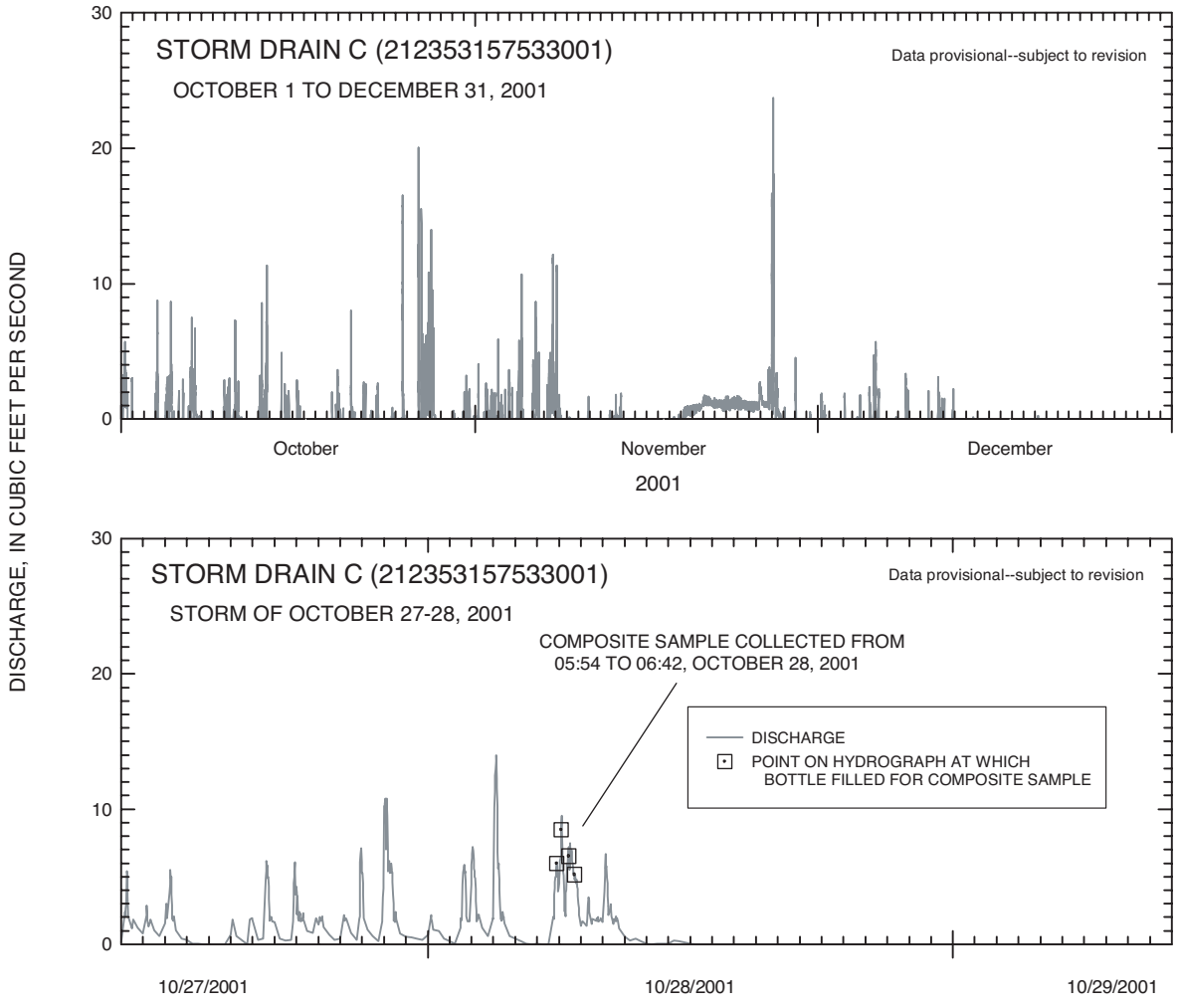

Figure 5. Stream discharge at Storm drain C gaging station (212353157533001) for October 1 to December 31, 2001; and detail for the 2-day period from 10:00 October 27, 2001 to 10:00 October 29, 2001, Oahu, Hawaii.

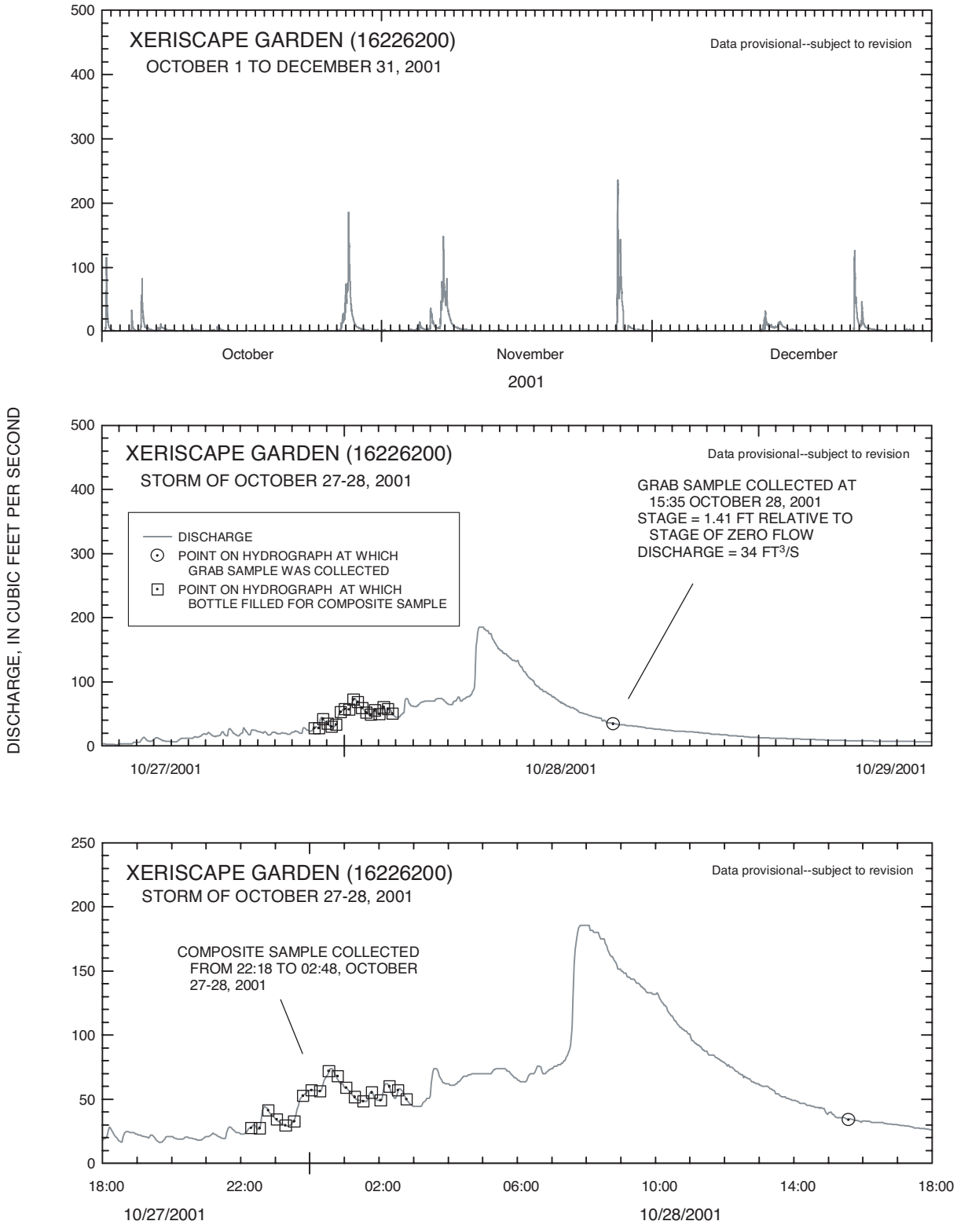

Figure 6. Stream discharge at Xeriscape garden gaging station (16226200) for October 1 to December 31, 2001; detail for the 2-day period from 10:00 October 27, 2001 to 10:00 October 29, 2001; and detail for the 24-hour period from 18:00 October 27, 2001 to 18:00, October 28, 2001, Oahu, Hawaii.

about 20 ft, and the discharge was concentrated in the middle 6 ft at the sampled cross section. An isokinetic sampler was used to collect the sample. A field duplicate was collected at this site. Discharge was measured concurrently with sample collection using a current meter.

Storm drain C.--No grab sample was collected at Storm drain C for this storm. At the time of grab sample collection, which was about 6 to 7 hours after the last peak in discharge in the storm drain, discharge had receded to nearly zero flow.

A flow-weighted, time-composite sample was created using four samples collected by the automatic sampler during the most coherent discharge peak sampled (fig. 5). Other samples were collected by the automatic sampler during the previous day, but not used for the composite sample.

Xeriscape garden.--The grab sample was collected using the EWI method at 15 sampling points distributed about every 1 ft along the cross section of the stream. Stream width was about 17 ft. An isokinetic sampler was used to collect the sample. A laboratory spike sample was collected at this site. Discharge associated with the grab sample was determined using the stage at the mean time of grab-sample collection and the stage-discharge rating for this gage.

A flow-weighted, time-composite sample was created by combining 19 samples from the automatic sam-

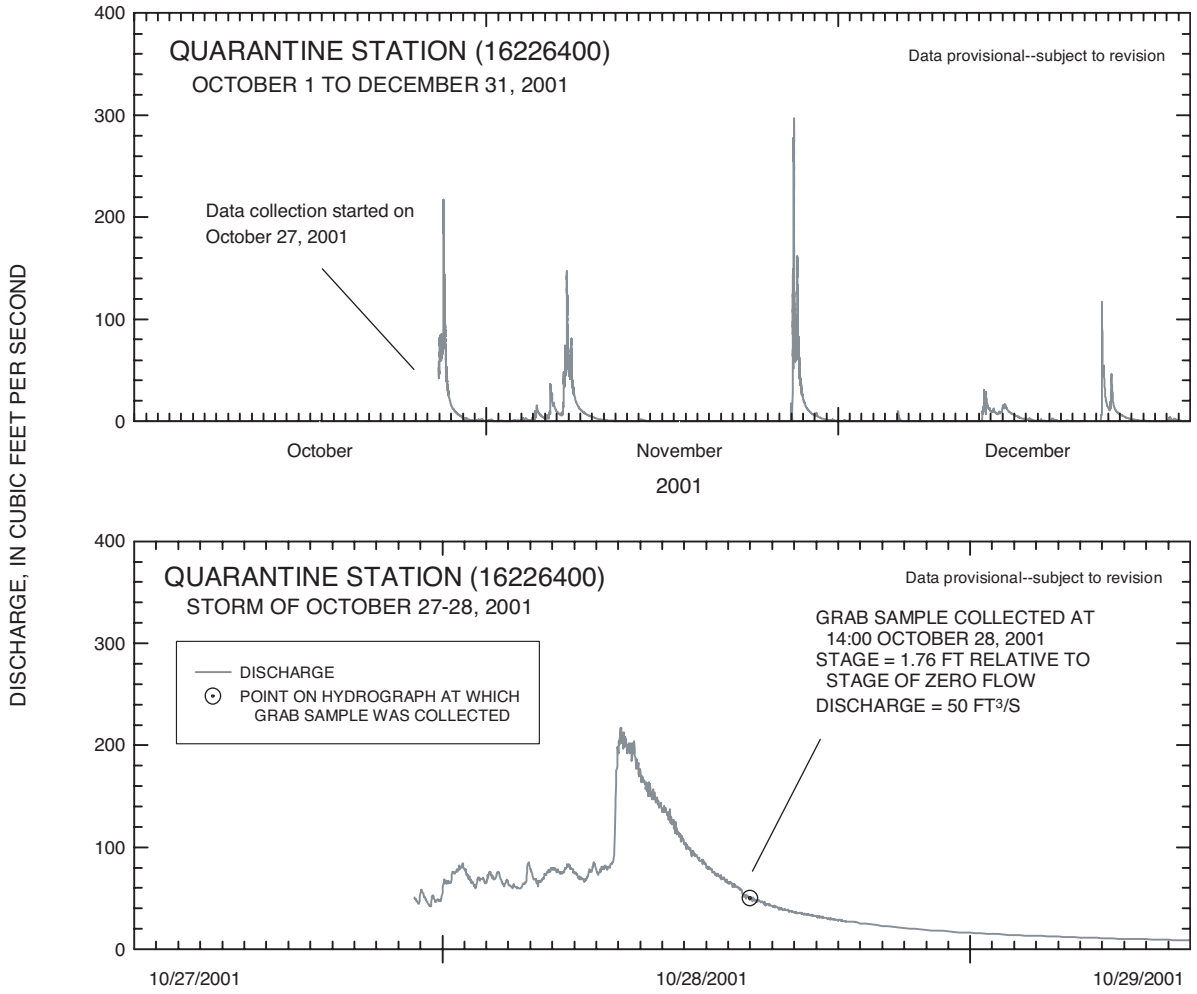

Figure 7. Stream discharge at Quarantine station gaging station (16226400) for October 1 to December 31, 2001; and detail for the 2-day period from 10:00 October 27, 2001 to 10:00 October 29, 2001, Oahu, Hawaii.

pler. The samples were collected during the initial rise of the stream (fig. 6).

Quarantine station.--The grab sample was collected using the EWI method at 17 sampling points, spaced about 1 ft apart, along the cross section of the stream. Stream width was about 18 ft. An isokinetic sampler was used to collect the sample. Sample water from this site also was used for a laboratory duplicate sample. Discharge associated with the grab sample was determined using the stage at the mean time of grab-sample collection and the stage-discharge rating for this gage.

Stadium.--A grab sample was collected at intervals spaced about 1 ft apart, using a HDPE 1-liter open-mouth bottle because of the shallow depths and swift-moving water. Stream width was about 50 ft. Discharge measurement was made using a current meter.

Analytical Results and Loads

The samples were analyzed for all of the constituents listed in the Stormwater Monitoring Program Plan (State of Hawaii Department of Transportation, 2000). Temperature, pH, and specific-conductance values from field measurements are shown in table 8. Constituent concentrations and instantaneous loads for the four grab samples are shown in table 9, constituent concentrations and average loads for the two composite samples are shown in table 10.

Table 6. Hydrologic conditions during grab-sample collection, October 28, 2001, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision
[--, no data; ft^3/s, cubic feet per second]

Abbreviated station name and station number	Date and time of peak discharge	Peak stage (feet over stage of zero flow)	Peak discharge (ft^3/s)	Date and time of grab- sample collection	Stage at time of grab-sample collection, (feet above stage of zero flow)	Discharge at time of grab- sample collection, (ft^3/s)
Bridge 8 (212356157531801)	--	--	--	10/28/2001 13:10	1.17	45
Storm drain C (212353157533001)	10/28/2001 03:08	1.61	14	stage too low to sample at time of sampling	--	--
Xeriscape garden (16226200)	10/28/2001 07:49	2.69	185	10/28/2001 15:35	1.41	34
Quarantine station (16226400)	10/28/2001 08:06	2.91	219[a]	10/28/2001 14:00	1.76	50
Stadium (16227100)	--	--	--	10/28/2001 12:40	0.48	69

[a] The stage-discharge relationship at the Quarantine station gaging station is not well defined at stage values greater than about 2.8 ft above the stage of zero flow, corresponding to a discharge of about 200 ft^3/s. These discharge values are estimates.

Table 7. Hydrologic conditions and sampling data during composite-sample collection, October 27–28, 2001, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision
[ft^3/s, cubic feet per second]

Abbreviated station name and station number	Date and time of peak discharge	Peak discharge (ft^3/s)	Beginning and ending dates and times of automatic-sample collection	Number of samples used for composite sample	Range of discharge at times of sample collection (ft^3/s)	Average discharge during sample collection (ft^3/s)	Compositing technique and notes
Storm drain C (212353157533001)	10/28/2001 03:08	14	10/28/2001 05:54 to 10/28/2001 06:42	4	5.2–8.5	6.5	flow weighted
Xeriscape garden (16226200)	10/28/2001 07:49	185	10/27/2001 22:18 to 10/28/2001 02:48	19	27–72	47	flow weighted

Table 8. Temperature, pH, and specific-conductance field measurements for grab samples collected on October 28, 2001, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision
[°C, degrees Celsius; µS/cm, microsiemens per centimeter]

Physical property	Unit	Reporting level	Abbreviated station name and number: Bridge 8 (212356157531801)	Xeriscape garden (16226200)	Quarantine station (16226400)	Stadium (16227100)
Temperature	°C	nearest 0.5°C	21.5	21.5	22.0	23.5
pH	pH	nearest 0.1	7.2	7.1	7.4	5.9
Specific conductance	µS/cm	nearest whole number	146	157	151	145

Table 9. Concentrations and instantaneous loads of physical properties and constituents for grab samples collected from Halawa Stream drainage basin on October 28, 2001, Oahu, Hawaii.

Data provisional--subject to revision.

[Conc., concentration; Instant. load, instantaneous load; na, not applicable; <, actual value is less than value shown; ≤, actual value is less than or equal to value shown; >, actual value is greater than value shown; e, estimated value; mg/L, milligrams per liter; µg/L, micrograms per liter; MPN/100 mL, most probable number (of colonies) per 100 milliliters; loads reported as lbs/day, pounds per day]

Physical property or constituent	Concentration unit	Instantaneous load unit	Minimum reporting level for concentration[a]	Abbreviated station name and number							
				Bridge 8 (212356157531801)		Xeriscape garden (16226200)		Quarantine station (16226400)		Stadium (16227100)	
				Conc.	Instant. load[f]	Conc.	Instant. load[f]	Conc.	Instant. load[f]	Conc.	Instant. load[f]
Chemical oxygen demand	mg/L	lbs/day	10	11	2,700	10	1,800	15	4,000	17	6,300
Total suspended solids	mg/L	lbs/day	10	<10	<2,400	<10	<1,800	11	3,000	5,380	2,000,000
Total dissolved solids	mg/L	lbs/day	10	86	21,000	96	18,000	92	25,000	90	33,000
Nitrogen, total organic + ammonia[b]	mg/L	lbs/day	0.10	0.20	49	0.17	31	0.23	62	0.30	110
Ammonia, dissolved, as N[c]	mg/L	lbs/day	0.040	<0.040	9.7	<0.040	<7.3	<0.040	<11	<0.040	<15
Nitrogen, nitrite, dissolved, as N[c]	mg/L	lbs/day	0.008	<0.008	2	<0.008	<1	<0.008	<2	<0.008	<3
Nitrate + nitrite, dissolved, as N[c]	mg/L	lbs/day	0.050	0.052	13	0.050	9.2	e0.042	e11	e0.043	e16
Total nitrogen, as N[d]	mg/L	lbs/day	na	0.25	61	0.22	40	e0.27	e73	e0.34	e130
Organic nitrogen, as N[e]	mg/L	lbs/day	na	≤0.20	≤49	≤0.17	≤31	≤0.23	≤62	≤0.30	≤110
Total phosphorus, as P	mg/L	lbs/day	0.060	e0.032	e7.8	<0.060	<11	e0.043	e12	e0.036	e13
Dissolved phosphorous, as P	mg/L	lbs/day	0.060	<0.060	<15	<0.060	<11	<0.060	<16	<0.060	<22
Total cadmium	µg/L	lbs/day	0.04	<0.04	<0.01	<0.04	<0.007	<0.04	<0.01	<0.04	<0.01
Total copper	µg/L	lbs/day	0.6	2.0	0.49	1.2	0.22	1.2	0.32	3.7	1.4
Total lead	µg/L	lbs/day	1	<1	<0.2	<1	<0.2	<1	<0.3	<1	<0.4
Total zinc	µg/L	lbs/day	1	2	0.5	<1	<0.2	<1	<0.3	7	3
Oil and grease	mg/L	lbs/day	7	<7	<2,000	<7	<1,000	<7	<2,000	<7	<3,000
Total petroleum hydrocarbons	mg/L	lbs/day	2	<2	<500	<2	<400	<2	<500	<2	<700
Biologic oxygen demand	mg/L	lbs/day	1	1	200	1	200	1	300	1	400
Fecal coliform	MPN/100mL	billion colonies per day	2	>16,000	>18,000	>16,000	>13,000	>16,000	>20,000	>16,000	>27,000

[a] Minimum reporting levels are based on values published by the USGS National Water Quality Laboratory.

[b] Nitrogen, total organic + ammonia is total Kjeldahl nitrogen.

[c] Ammonia, nitrite, and nitrate + nitrite are analyzed from filtrate. In January 1993, USGS National Water Quality Laboratory analyses for total ammonia, total nitrite, and total nitrate + nitrite were discontinued and only dissolved ammonia, dissolved nitrite, and dissolved nitrate + nitrite were analyzed after that date. Values for the total and for the dissolved constituents were statistically indistinguishable (U.S. Geological Survey Office of Water Quality Technical Memorandum 93.04). USGS National Water Quality Laboratory methods for these constituents are different from USEPA methods; however, USGS methods have similar or more accurate results.

[d] Total nitrogen is calculated by adding nitrogen, total organic + ammonia (Kjeldahl) to nitrate + nitrite, dissolved. If the concentration value of nitrate + nitrite, dissolved is estimated and below the minimum reporting level, the concentration value of total nitrogen is reported as the sum of the values shown for nitrogen, total organic + ammonia and nitrate + nitrite, dissolved, and noted as estimated.

[e] Organic nitrogen is calculated by subtracting ammonia, dissolved, from nitrogen, total organic + ammonia (Kjeldahl). If the concentration value of ammonia, dissolved is below the minimum reporting level, the concentration value for organic nitrogen is reported as less than or equal to the value of total organic + ammonia (Kjeldahl), which represents the maximum possible value for organic nitrogen.

[f] Instantaneous load is computed from the concentration value and the discharge at the mean time of sample collection.

Table 10. Concentrations and average loads of physical properties and constituents for composite samples collected from Halawa Stream drainage basin on October 28, 2001, Oahu, Hawaii.
Data provisional--subject to revision.

[Conc., concentration; na, not applicable; <, actual value is less than value shown; ≤, actual value is less than or equal to value shown; e, estimated value; mg/L, milligrams per liter; µg/L, micrograms per liter; loads reported as lbs/day, pounds per day]

Physical property or constituent	Concentration unit	Composite sample average load unit	Minimum reporting level for concentration[a]	Abbreviated station name and number: Storm drain C (212353157533001) Conc.	Storm drain C (212353157533001) Average load[f]	Xeriscape garden (16226200) Conc.	Xeriscape garden (16226200) Average load[f]
Chemical oxygen demand	mg/L	lbs/day	10	<10	<350	27	6,800
Total suspended solids	mg/L	lbs/day	10	<10	<350	33	8,400
Total dissolved solids	mg/L	lbs/day	10	28	980	82	21,000
Nitrogen, total organic + ammonia[b]	mg/L	lbs/day	0.10	<0.10	<3.5	0.54	140
Ammonia, dissolved, as N[c]	mg/L	lbs/day	0.040	<0.040	<1.4	<0.040	<10
Nitrogen, nitrite, dissolved, as N[c]	mg/L	lbs/day	0.008	<0.008	<0.3	<0.008	<2
Nitrate + nitrite, dissolved, as N[c]	mg/L	lbs/day	0.050	<0.050	<1.8	<0.050	<13
Total nitrogen, as N[d]	mg/L	lbs/day	na	<0.15	<5.3	<0.59	<150
Organic nitrogen, as N[e]	mg/L	lbs/day	na	<0.10	<3.5	≤0.54	≤140
Total phosphorus, as P	mg/L	lbs/day	0.060	<0.060	<2.1	0.070	18
Dissolved phosphorous, as P	mg/L	lbs/day	0.060	<0.060	<2.1	<0.060	<15
Total cadmium	µg/L	lbs/day	0.04	e0.02	e0.0007	<0.04	<0.01
Total copper	µg/L	lbs/day	0.6	1.4	0.049	1.7	0.43
Total lead	µg/L	lbs/day	1	<1	<0.04	<1	<0.3
Total zinc	µg/L	lbs/day	1	12	0.42	<1	<0.3

[a] Minimum reporting levels are based on values published by the USGS National Water Quality Laboratory.
[b] Nitrogen, total organic + ammonia is total Kjeldahl nitrogen.
[c] Ammonia, nitrite, and nitrate + nitrite are analyzed from filtrate. In January 1993, USGS National Water Quality Laboratory analyses for total ammonia, total nitrite, and total nitrate + nitrite were discontinued and only dissolved ammonia, dissolved nitrite, and dissolved nitrate + nitrite were analyzed after that date. Values for the total and for the dissolved constituents were statistically indistinguishable (U.S. Geological Survey Office of Water Quality Technical Memorandum 93.04). USGS National Water Quality Laboratory methods for these constituents are different from USEPA methods; however, USGS methods have similar or more accurate results.
[d] Total nitrogen is calculated by adding nitrogen, total organic + ammonia (Kjeldahl) to nitrate + nitrite, dissolved. If the concentration value of either nitrogen, total organic + ammonia or nitrate + nitrite, dissolved is below the minimum reporting level, the concentration value of total nitrogen is reported as less than the sum of the values shown for nitrogen, total organic + ammonia and nitrate + nitrite, dissolved, which represents the maximum possible value for total nitrogen.
[e] Organic nitrogen is calculated by subtracting ammonia, dissolved, from nitrogen, total organic + ammonia (Kjeldahl). If the concentration value of ammonia, dissolved is below the minimum reporting level, the concentration value for organic nitrogen is reported as less than or equal to the value of total organic + ammonia (Kjeldahl). If both concentration values of nitrogen, total organic + ammonia (Kjeldahl) and ammonia, dissolved are below the minimum reporting level, the concentration value for organic nitrogen is reported as less than the value of total organic + ammonia (Kjeldahl). In both cases, the concentration value represents the maximum possible value for organic nitrogen.
[f] Average load is computed from the concentration value and the average discharge during sample collection.

Storm of January 26–27, 2002

Hydrologic Conditions During Sampling and Data Collection

Hydrographs of streamflow at Storm drain C, Xeriscape garden, and Quarantine station sites during the storm of January 26–27, 2002 are shown in figures 8, 9, and 10, respectively. Heavy rainfall during the early evening and again near midnight on January 26, 2002, resulted in a double-peaked hydrograph. Discharge for the two peaks was about 513 and 797 ft^3/s, respectively, at the Xeriscape garden gaging station, and about 720 and 701 ft^3/s at the Quarantine station gaging station (figs. 9 and 10).

The hydrograph for the Quarantine station also shows estimated discharge based on the discharge from the Xeriscape garden gage. The stage-discharge rating for the Quarantine station gaging station was not well defined at discharges above 200 to 300 ft^3/s because of the limited data from this recently established gage. The rating for the Xeriscape garden gage was much better defined at higher flows. These two sites are about 5,000 ft apart, and it is likely that the discharge was similar at these two sites. However, the hydrograph (fig. 10) shows about 150 ft^3/s less discharge during the second peak than the equivalent peak on the hydrograph for the Xeriscape garden gage (fig. 9).

The times of peak flow, and the times of grab-sample collection and corresponding discharges at the times of sample collection, are listed in table 11. The number of samples collected by the automatic samplers and used for the composite samples, the beginning and end times of sample collection by the automatic samplers, and the average discharges during the collection of the composite samples are shown in table 12. Sample-collection times also are displayed in the hydrographs (figs. 8, 9, and 10).

Sampling and Discharge Measurement Methods

Grab and composite samples were collected using water collected from the automatic samplers at the Storm drain C, Xeriscape garden, and Quarantine station sites. The timing of the peak discharge during the night prevented the collection of manual grab samples. Temperature measurements were not made because the samples were removed from the automatic samplers more than 12 hours after they were collected. Fecal coliform and biological oxygen demand samples were not collected because of potential contamination from non-sterilized sampling apparatus. Qa/qc samples were not collected because of the limited volumes of sample from each site.

Storm drain C.--The first 5 samples of the 24 collected from the automatic sampler were used for the grab sample. The first three samples collected by the automatic sampler were used to fill bottles for oil and grease, and total petroleum hydrocarbon analyses. The fourth and fifth samples were combined in a churn and processed for the other analyses. Discharge associated with the grab sample was determined using the stage at the mean time of the first five samples collected by the automatic sampler, and the stage-discharge rating for this gage.

A flow-weighted, time-composite sample was created by combining the remaining 19 samples from the automatic sampler.

Xeriscape garden.--The first 5 samples of the 24 collected from the automatic sampler were used for the grab sample. The first three samples collected by the automatic sampler were used to fill bottles for oil and grease, and total petroleum hydrocarbon analyses. The fourth and fifth samples were combined in a churn and processed for the other analyses. Discharge associated with the grab sample was determined using the stage at the mean time of the first five samples collected by the automatic sampler, and the stage-discharge rating for this gage.

A flow-weighted, time-composite sample was created by combining 17 of the remaining 19 samples from the automatic sampler (two bottles in the sampler did not fill properly). The composite sample was collected throughout the first peak of discharge over a period of about 2 hours (fig. 9).

Quarantine station.--The first five samples from the automatic sampler did not contain enough water for the grab sample (some of the automatic sampler bottles did not fill properly).

A flow-weighted, time-composite sample was created by combining 18 samples from the automatic sampler. The composite sample was collected throughout the first peak of discharge over a period of about 2 hours (fig. 10).

Analytical Results and Loads

The samples were analyzed for all of the constituents listed in the Stormwater Monitoring Program Plan (State of Hawaii Department of Transportation, 2000),

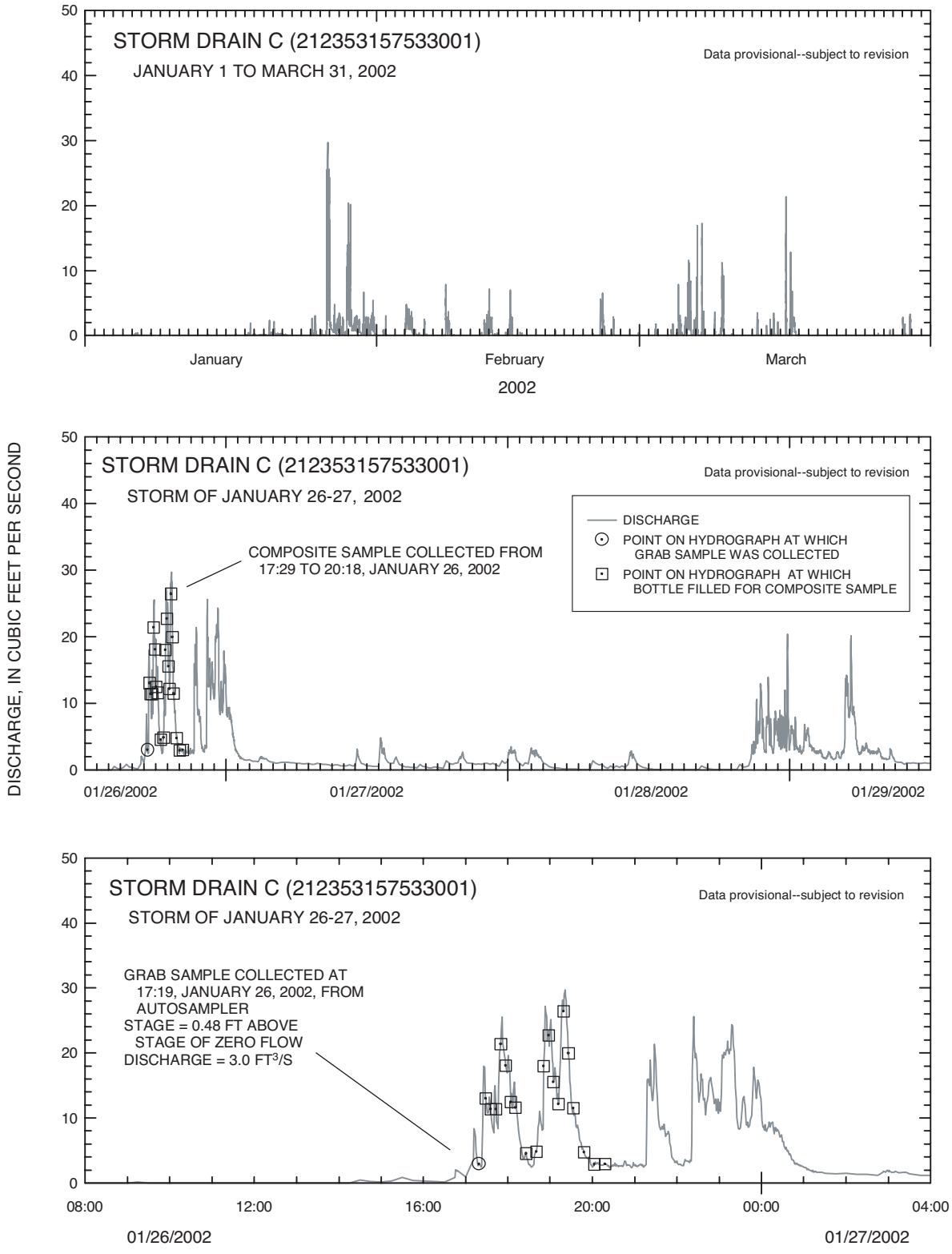

Figure 8. Stream discharge at Storm drain C gaging station (212353157533001) for January 1 to March 31, 2002; detail for the 3-day period from 12:00 January 26, 2002 to 12:00 January 29, 2002; and detail for the 20-hour period from 08:00 January 26, 2002 to 04:00 January 27, 2002, Oahu, Hawaii.

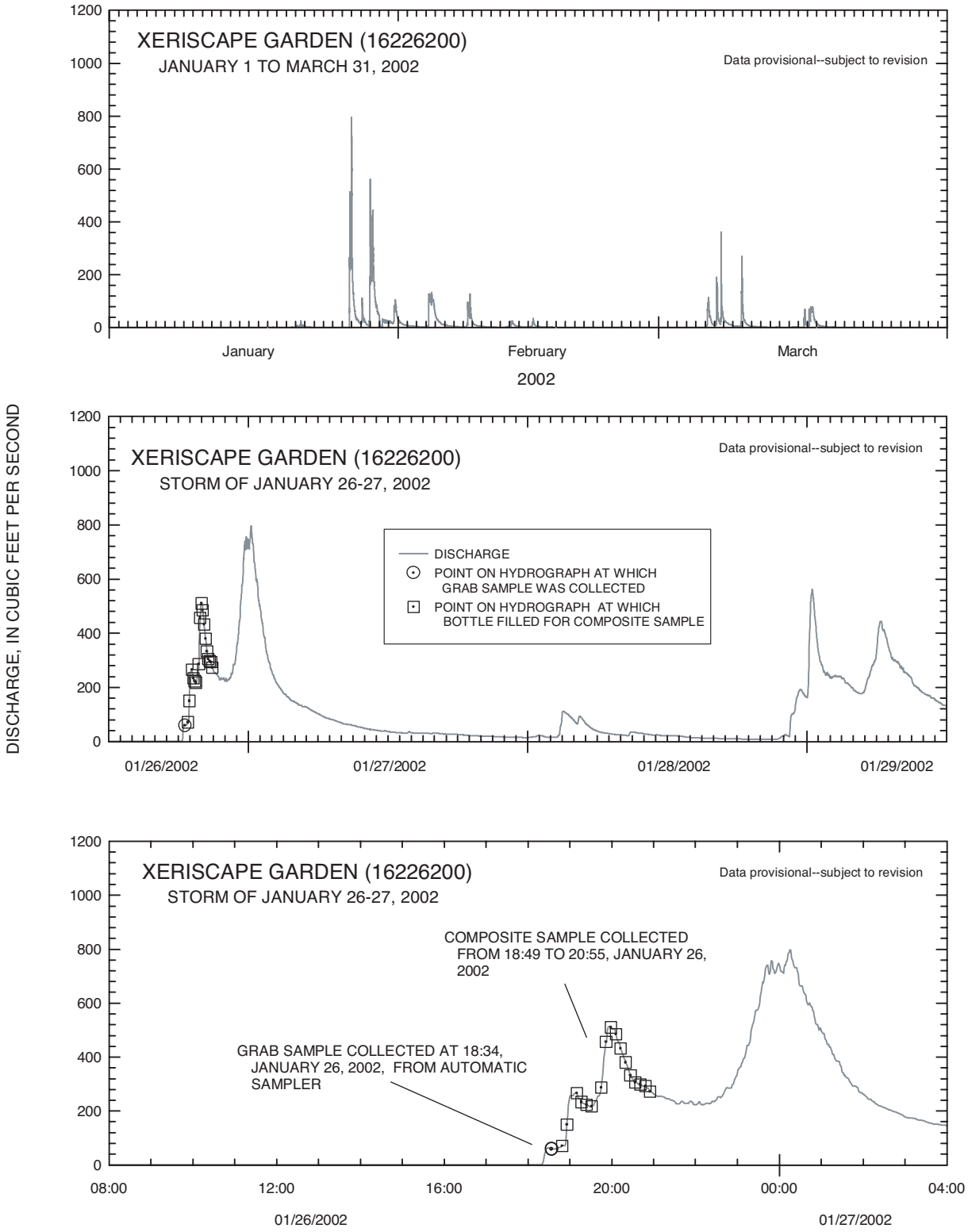

Figure 9. Stream discharge at Xeriscape garden gaging station (16226200) for January 1 to March 31, 2002; detail for the 3-day period from 12:00 January 26, 2002 to 12:00 January 29, 2002; and detail for the 20-hour period from 08:00 January 26, 2002 to 04:00 January 27, 2002, Oahu, Hawaii.

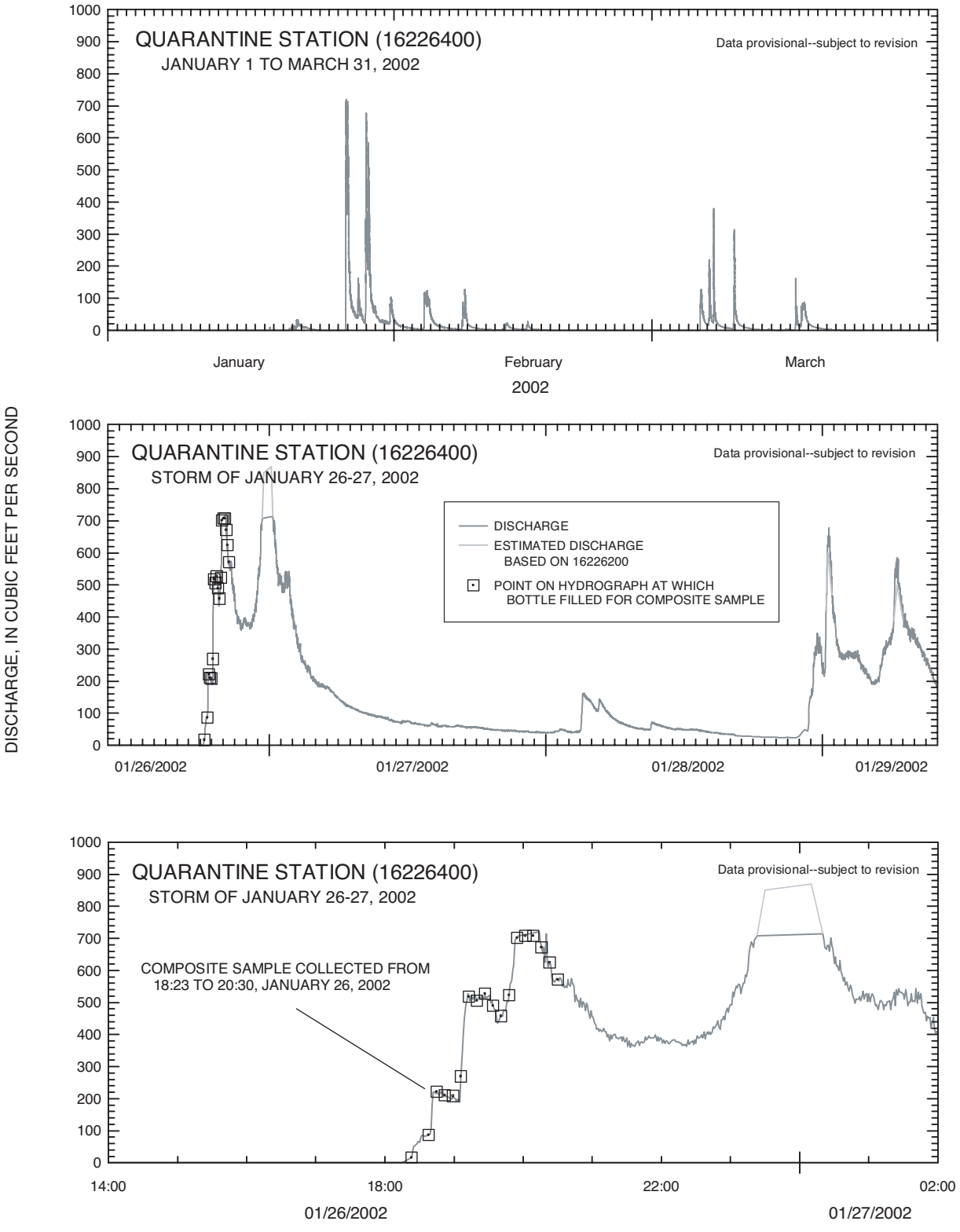

Figure 10. Stream discharge at Quarantine station gaging station (16226400) for January 1 to March 31, 2002; detail for the 3-day period from 10:00 January 26, 2002 to 10:00 January 29, 2002; and detail for the 12-hour period from 14:00 January 26, 2002 to 02:00 January 27, 2002, Oahu, Hawaii.

except for fecal coliform and biological oxygen demand. Table 13 shows pH and specific conductance for the two grab samples. Constituent concentrations and instantaneous loads for the two grab samples are shown in table 14, constituent concentrations and average loads for the three composite samples are shown in table 15.

Table 11. Hydrologic conditions during grab-sample collection, January 26–27, 2002, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision
[--, no data; ft^3/s, cubic feet per second]

Abbreviated station name and station number	Date and time of peak discharge	Peak stage (feet over stage of zero flow)	Peak discharge (ft^3/s)	Date and time of grab- sample collection	Stage at time of grab-sample collection, (feet above stage of zero flow)	Discharge at time of grab- sample collection, (ft^3/s)
Storm drain C (212353157533001)	01/26/2002 19:21	2.88	30	01/26/2002 17:19	0.48	3.0
Xeriscape garden (16226200)	01/26/2002 19:55 and 01/27/2002 00:15	3.99 and 4.72	513 and 797	01/26/2002 18:34	1.74	59
Quarantine station (16226400)	01/26/2002 20:14 and 01/27/2002 00:27	4.34 and 4.31	720 and 701[a]	not enough sample collected in autosampler for grab sample	--	--

[a] The stage-discharge relationship at the Quarantine station gaging station is not well defined at stage values greater than about 2.8 ft above the stage of zero flow, corresponding to a discharge of about 200 ft^3/s. These discharge values are estimates.

Table 12. Hydrologic conditions and sampling data during composite-sample collection, January 26–27, 2002, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision
[ft^3/s, cubic feet per second]

Abbreviated station name and station number	Date and time of peak discharge	Peak discharge (ft^3/s)	Beginning and ending dates and times of automatic-sample collection	Number of samples used for composite sample	Range of discharge at times of sample collection (ft^3/s)	Average discharge during sample collection (ft^3/s)	Compositing technique and notes
Storm drain C (212353157533001)	01/26/2002 19:21	30	01/26/2002 17:29 to 01/26/2002 20:18	19	2.9 –26	11	flow weighted
Xeriscape garden (16226200)	01/26/2002 19:55 and 01/27/2002 00:15	513 and 797	01/26/2002 18:49 to 01/26/2002 20:55	17	70–510	303	flow weighted
Quarantine station (16226400)	01/26/2002 20:14 and 01/27/2002 00:27	720 and 701[a]	01/26/2002 18:23 to 01/26/2002 20:30	18	16–708[a]	401[a]	flow weighted except for one bottle

[a] The stage-discharge relationship at the Quarantine station gaging station is not well defined at stage values greater than about 2.8 ft above the stage of zero flow, corresponding to a discharge of about 200 ft^3/s. These discharge values are estimates.

Table 13. Temperature, pH, and specific-conductance field measurements for grab samples collected on January 26, 2002, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision
[°C, degrees Celsius; µS/cm, microsiemens per centimeter]

Physical property	Unit	Reporting level	Abbreviated station name and number: Storm drain C (212353157533001)	Abbreviated station name and number: Xeriscape garden (16226200)
Temperature	°C	nearest 0.5°C	no measurement	no measurement
pH	pH	nearest 0.1	7.7	7.5
Specific conductance	µS/cm	nearest whole number	78	83

Table 14. Concentrations and instantaneous loads of physical properties and constituents for grab samples collected from Halawa Stream drainage basin on January 26, 2002, Oahu, Hawaii.

Data provisional--subject to revision.

[Conc., concentration; Instant. load, instantaneous load; na, not applicable; <, actual value is less than value shown; ≤, actual value is less than or equal to value shown; e, estimated value; mg/L, milligrams per liter; µg/L, micrograms per liter; loads reported as lbs/day, pounds per day]

Physical property or constituent	Concentration unit	Instantaneous load unit	Minimum reporting level for concentration[a]	Abbreviated station name and number: Storm drain C (212353157533001) Conc.	Storm drain C (212353157533001) Instant. load[f]	Xeriscape garden (16226200) Conc.	Xeriscape garden (16226200) Instant. load[f]
Chemical oxygen demand	mg/L	lbs/day	10	40	650	33	11,000
Total suspended solids	mg/L	lbs/day	10	64	1,000	<10	<3,200
Total dissolved solids	mg/L	lbs/day	10	30	500	54	17,000
Nitrogen, total organic + ammonia[b]	mg/L	lbs/day	0.10	0.53	8.6	0.85	270
Ammonia, dissolved, as N[c]	mg/L	lbs/day	0.040	<0.040	<0.65	<0.040	<13
Nitrogen, nitrite, dissolved, as N[c]	mg/L	lbs/day	0.008	<0.008	<0.1	<0.008	<3
Nitrate + nitrite, dissolved, as N[c]	mg/L	lbs/day	0.050	e0.030	e0.49	0.098	31
Total nitrogen, as N[d]	mg/L	lbs/day	na	e0.56	e9.1	0.95	300
Organic nitrogen, as N[e]	mg/L	lbs/day	na	≤0.53	≤8.6	≤0.85	≤270
Total phosphorus, as P	mg/L	lbs/day	0.060	0.177	2.9	0.217	69
Dissolved phosphorous, as P	mg/L	lbs/day	0.060	<0.060	<0.97	e0.037	e12
Total cadmium	µg/L	lbs/day	0.04	0.31	0.0050	0.11	0.035
Total copper	µg/L	lbs/day	0.6	34.3	0.56	17.0	5.4
Total lead	µg/L	lbs/day	1	12	0.19	4	1
Total zinc	µg/L	lbs/day	1	133	2.2	46	15
Oil and grease	mg/L	lbs/day	7	e5	e80	<7	<2,000
Total petroleum hydrocarbons	mg/L	lbs/day	2	<2	<30	<2	<600

[a] Minimum reporting levels are based on values published by the USGS National Water Quality Laboratory.

[b] Nitrogen, total organic + ammonia is total Kjeldahl nitrogen.

[c] Ammonia, nitrite, and nitrate + nitrite are analyzed from filtrate. In January 1993, USGS National Water Quality Laboratory analyses for total ammonia, total nitrite, and total nitrate + nitrite were discontinued and only dissolved ammonia, dissolved nitrite, and dissolved nitrate + nitrite were analyzed after that date. Values for the total and for the dissolved constituents were statistically indistinguishable (U.S. Geological Survey Office of Water Quality Technical Memorandum 93.04). USGS National Water Quality Laboratory methods for these constituents are different from USEPA methods; however, USGS methods have similar or more accurate results.

[d] Total nitrogen is calculated by adding nitrogen, total organic + ammonia (Kjeldahl) to nitrate + nitrite, dissolved. If the concentration value of nitrate + nitrite, dissolved is estimated and below the minimum reporting level, the concentration value of total nitrogen is reported as the sum of the values shown for nitrogen, total organic + ammonia and nitrate + nitrite, dissolved, and noted as estimated.

[e] Organic nitrogen is calculated by subtracting ammonia, dissolved, from nitrogen, total organic + ammonia (Kjeldahl). If the concentration value of ammonia, dissolved is below the minimum reporting level, the concentration value for organic nitrogen is reported as less than or equal to the value of total organic + ammonia (Kjeldahl), which represents the maximum possible value for organic nitrogen.

[f] Instantaneous load is computed from the concentration value and the discharge at the mean time of sample collection.

Table 15. Concentrations and average loads of physical properties and constituents for composite samples collected from Halawa Stream drainage basin on January 26, 2002, Oahu, Hawaii.

Data provisional--subject to revision.

[Conc., concentration; na, not applicable; <, actual value is less than value shown; ≤, actual value is less than or equal to value shown; e, estimated value; mg/L, milligrams per liter; µg/L, micrograms per liter; loads reported as lbs/day, pounds per day]

Physical property or constituent	Concentration unit	Composite sample average load unit	Minimum reporting level for concentration[a]	Abbreviated station name and number					
				Storm drain C (212353157533001)		Xeriscape garden (16226200)		Quarantine station (16226400)	
				Conc.	Average load[f]	Conc.	Average load[f]	Conc.	Average load[f]
Chemical oxygen demand	mg/L	lbs/day	10	16	950	290	474,000	380	822,000
Total suspended solids	mg/L	lbs/day	10	20	1,200	2,010	3,290,000	2,370	5,130,000
Total dissolved solids	mg/L	lbs/day	10	20	1,200	56	92,000	58	130,000
Nitrogen, total organic + ammonia[b]	mg/L	lbs/day	0.10	0.14	8.3	7.2	12,000	7.8	17,000
Ammonia, dissolved, as N[c]	mg/L	lbs/day	0.040	<0.040	<2.4	<0.040	<65	<0.040	<87
Nitrogen, nitrite, dissolved, as N[c]	mg/L	lbs/day	0.008	<0.008	<0.5	<0.008	<10	<0.008	<20
Nitrate + nitrite, dissolved, as N[c]	mg/L	lbs/day	0.050	<0.050	<3.0	0.203	332	0.220	476
Total nitrogen, as N[d]	mg/L	lbs/day	na	<0.19	<11	7.4	12,000	8.0	17,000
Organic nitrogen, as N[e]	mg/L	lbs/day	na	≤0.14	≤8.3	≤7.2	≤12,000	≤7.8	≤17,000
Total phosphorus, as P	mg/L	lbs/day	0.060	e0.048	e2.8	1.75	2,860	1.97	4,260
Dissolved phosphorous, as P	mg/L	lbs/day	0.060	<0.060	<3.6	<0.060	<98	<0.060	<130
Total cadmium	µg/L	lbs/day	0.04	0.09	0.005	0.34	0.56	0.52	1.1
Total copper	µg/L	lbs/day	0.6	12.4	0.74	94.0	154	119	257
Total lead	µg/L	lbs/day	1	3	0.2	11	18	23	50
Total zinc	µg/L	lbs/day	1	142	8.4	135	221	193	417

[a] Minimum reporting levels are based on values published by the USGS National Water Quality Laboratory.

[b] Nitrogen, total organic + ammonia is total Kjeldahl nitrogen.

[c] Ammonia, nitrite, and nitrate + nitrite are analyzed from filtrate. In January 1993, USGS National Water Quality Laboratory analyses for total ammonia, total nitrite, and total nitrate + nitrite were discontinued and only dissolved ammonia, dissolved nitrite, and dissolved nitrate + nitrite were analyzed after that date. Values for the total and for the dissolved constituents were statistically indistinguishable (U.S. Geological Survey Office of Water Quality Technical Memorandum 93.04). USGS National Water Quality Laboratory methods for these constituents are different from USEPA methods; however, USGS methods have similar or more accurate results.

[d] Total nitrogen is calculated by adding nitrogen, total organic + ammonia (Kjeldahl) to nitrate + nitrite, dissolved. If the concentration value of nitrate + nitrite, dissolved is below the minimum reporting level, the concentration value of total nitrogen is reported as less than the sum of the values shown for nitrogen, total organic + ammonia and nitrate + nitrite, dissolved, which represents the maximum possible value for total nitrogen.

[e] Organic nitrogen is calculated by subtracting ammonia, dissolved, from nitrogen, total organic + ammonia (Kjeldahl). If the concentration value of ammonia, dissolved is below the minimum reporting level, the concentration value for organic nitrogen is reported as less than or equal to the value of total organic + ammonia (Kjeldahl), which represents the maximum possible value for organic nitrogen.

[f] Average load is computed from the concentration value and the average discharge during sample collection.

Storm of January 28–29, 2002

Hydrologic Conditions During Sampling and Data Collection

Hydrographs of streamflow at Storm drain C, Xeriscape garden, and Quarantine station during the storm of January 28–29, 2002 are shown in figures 11, 12 and 13, respectively. Two discharge peaks occurred about 6 hours apart at the at the Xeriscape garden and Quarantine station sites. Discharge was high during this storm, reaching about 562 to 677 ft^3/s at the Xeriscape garden and Quarantine station sites, respectively. The hydrograph for the Quarantine station also shows estimated discharge based on the discharge from the Xeriscape garden gage.

The times of peak flow, and the times of grab-sample collection and corresponding discharges at the times of sample collection, are listed in table 16. The number of samples collected by the automatic samplers and used for the composite samples, the beginning and end times of sample collection by the automatic samplers, and the average discharges during the collection of the composite samples are shown in table 17. Sample-collection times also are displayed in the hydrographs (figs. 11, 12, and 13).

Sampling and Discharge Measurement Methods

Grab samples were collected at all five sites during the storm on January 28–29, 2002. Composite samples were collected at the Storm drain C, Xeriscape garden, and Quarantine station sites.

Bridge 8.-- A grab sample was collected along a single vertical line at the estimated fastest and deepest section of the stream. Discharge was concentrated in the middle 6 ft of the stream at the cross section. An isokinetic sampler attached to an aluminum pole was used to collect the sample. A laboratory duplicate was collected at this site. Discharge associated with the grab sample was determined using the stage at the mean time of grab-sample collection and the stage-discharge rating for this gage.

Storm drain C.--A grab sample was collected at the centroid of flow by directly submersing the churn. At the time of the manual grab-sample collection, the stage was only 0.18 ft above zero flow, and discharge was 0.98 ft^3/s (fig. 11). Discharge associated with the grab sample was determined using the stage at the mean time of grab-sample collection and the stage-discharge rating for this gage.

A flow-weighted, time-composite sample was created by combining 19 samples from the automatic sampler. The samples were collected during about a 2-hour period.

Xeriscape garden.--A grab sample was collected using a single vertical at the estimated fastest and deepest section of the stream. Discharge was concentrated in the middle of the stream cross section. An isokinetic sampler was used to collect the sample. Discharge associated with the grab sample was determined using the stage at the mean time of grab-sample collection and the stage-discharge rating for this gage.

A flow-weighted, time-composite sample was created by combining 24 samples from the automatic sampler. The samples were collected during the initial rise of the stream (fig. 12).

Quarantine station.--The grab sample was collected about 300 ft downstream from the gage at an abandoned roadway bridge. The sample was collected using the EWI method at 7 sampling points, spaced about 5 ft apart, along the cross-section of the stream. Stream width was about 37 ft. An isokinetic sampler connected to an aluminum pole was used to collect the sample. Sample water from this site also was used for a field duplicate. Discharge associated with the grab sample was determined using the stage at the mean time of grab-sample collection and the stage-discharge rating for this gage.

A flow-weighted, time-composite sample was created by combining 24 samples from the automatic sampler. The samples were collected during the initial rise of the stream (fig. 13).

Stadium.--The grab sample was collected using the EWI method at 11 sampling points, spaced about 5 ft apart, along the cross section of the concrete channel. An isokinetic sampler attached to an aluminum pole was used to collect the sample. Stream width was about 63 ft. A laboratory spike was collected at this site. Discharge was measured by the float method.

Analytical Results and Loads

The samples were analyzed for all of the constituents listed in the Stormwater Monitoring Program Plan (State of Hawaii Department of Transportation, 2000). Temperature, pH, and specific-conductance values from field measurements are shown in table 18. Constituent concentrations and instantaneous loads for the five grab samples are shown in table 19, constituent concentrations and average loads for the three composite samples are shown in table 20.

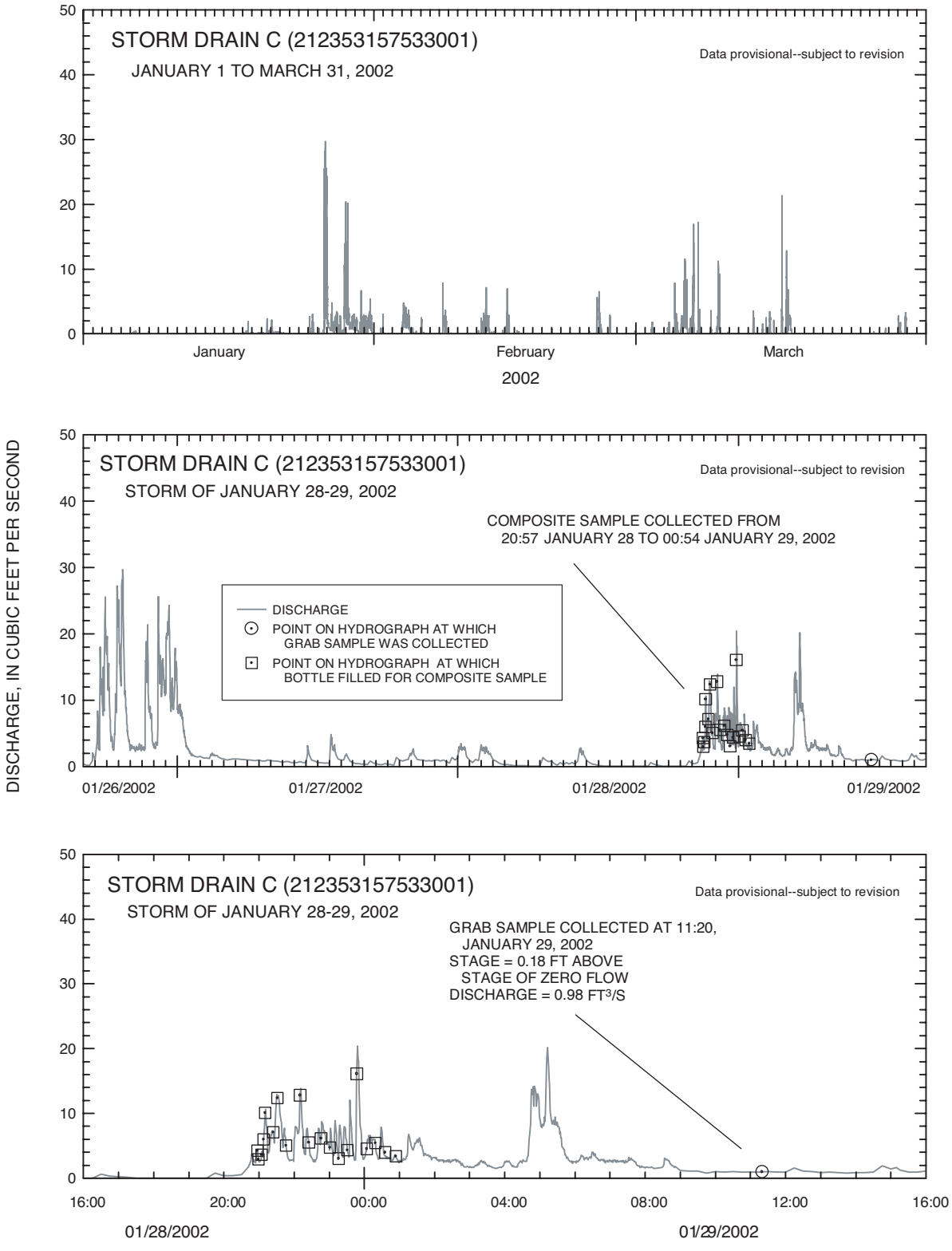

Figure 11. Stream discharge at Storm drain C gaging station (212353157533001) for January 1 to March 31, 2002; detail for the 3-day period from 16:00 January 26, 2002 to 16:00 January 29, 2002; and detail for the 24-hour period from 16:00 January 28, 2002 to 16:00 January 29, 2002, Oahu, Hawaii.

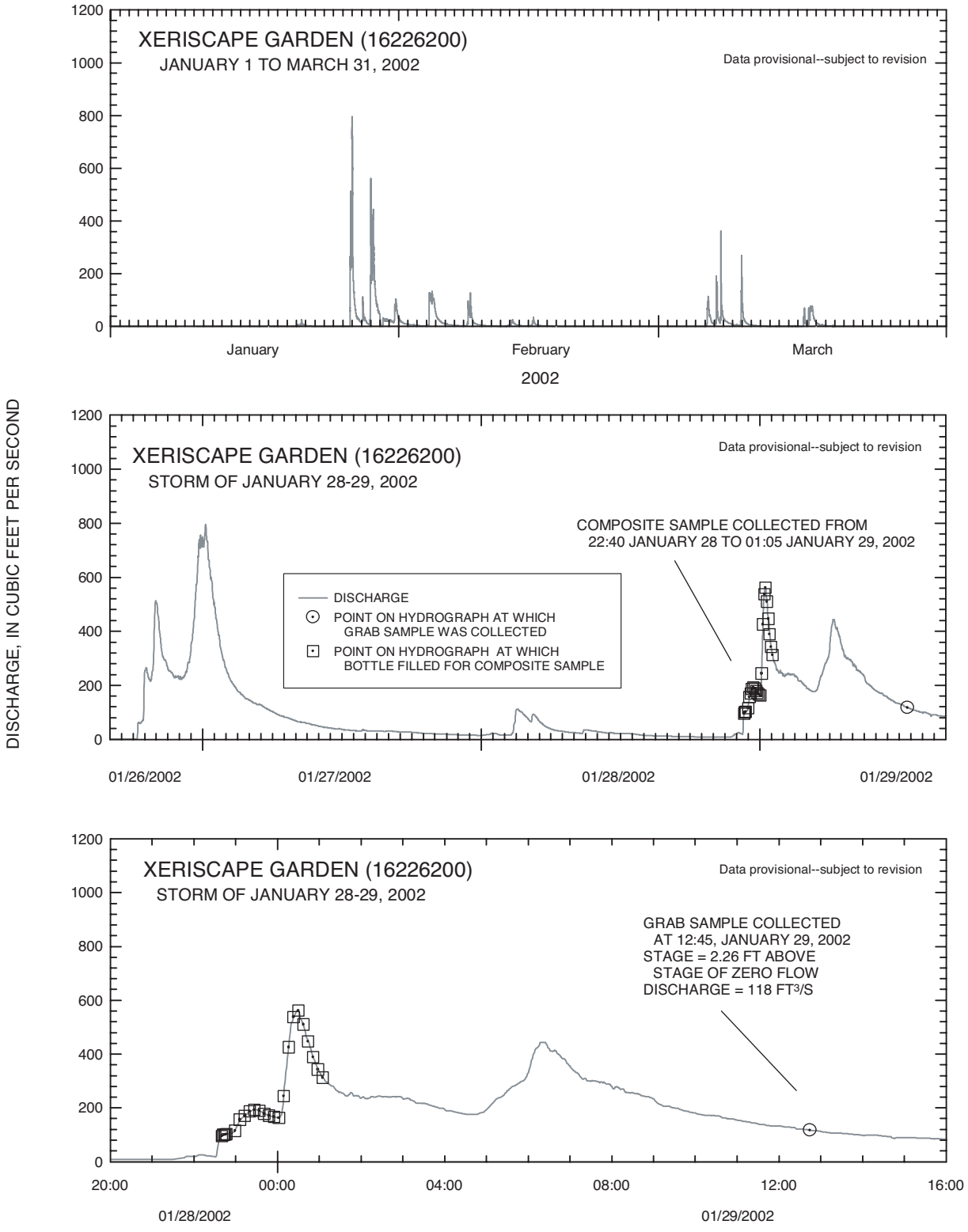

Figure 12. Stream discharge at Xeriscape garden gaging station (16226200) for January 1 to March 31, 2002; detail for the 3-day period from 16:00 January 26, 2002 to 16:00 January 29, 2002; and detail for the 20-hour period from 20:00 January 28, 2002 to 16:00 January 29, 2002, Oahu, Hawaii.

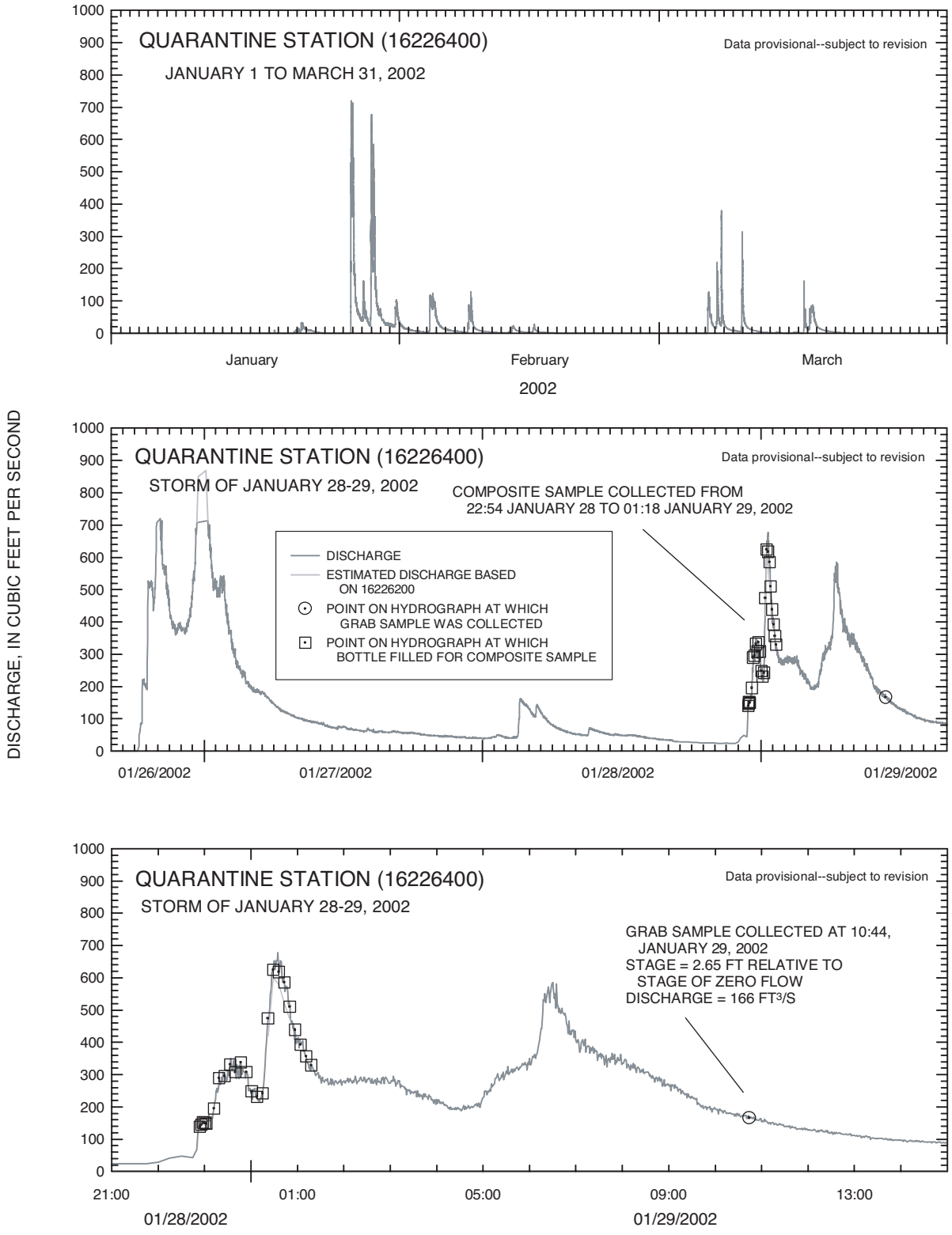

Figure 13. Stream discharge at Quarantine station gaging station (16226400) for January 1 to March 31, 2002; detail for the 3-day period from 16:00 January 26, 2002 to 16:00 January 29, 2002; and detail for the 18-hour period from 21:00 January 28, 2002 to 15:00 January 29, 2002, Oahu, Hawaii.

Table 16. Hydrologic conditions during grab-sample collection, January 28–29, 2002, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision
[--, no data; ft^3/s, cubic feet per second]

Abbreviated station name and station number	Date and time of peak discharge	Peak stage (feet over stage of zero flow)	Peak discharge (ft^3/s)	Date and time of grab- sample collection	Stage at time of grab- sample collection (feet above stage of zero flow)	Discharge at time of grab-sample collection, (ft^3/s)
Bridge 8 (212356157531801)	--	--	--	01/29/2002 10:10	1.77	88
Storm drain C (212353157533001)	01/28/2002 23:48	2.15	20	01/29/2002 11:20	0.18	0.98
Xeriscape garden (16226200)	01/29/2002 00:28 and 01/29/2002 06:17	4.13 and 3.77	562 and 444	01/29/2002 12:45	2.26	118
Quarantine station (16226400)	01/29/2002 00:35 and 01/29/2002 06:30	4.27 and 4.07	677 and 585[a]	01/29/2002 10:44	2.65	166
Stadium (16227100)	--	--	--	01/29/2002 13:04	0.76	300

[a]The stage-discharge relationship at the Quarantine station gaging station is not well defined at stage values greater than about 2.8 ft above the stage of zero flow, corresponding to a discharge of about 200 ft^3/s. These discharge values are estimates.

Table 17. Hydrologic conditions and sampling data during composite-sample collection, January 28–29, 2002, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision
[ft^3/s, cubic feet per second]

Abbreviated station name and station number	Date and time of peak discharge	Peak discharge (ft^3/s)	Beginning and ending dates and times of automatic-sample collection	Number of samples used for composite sample	Range of discharge at times of sample collection (ft^3/s)	Average discharge during sample collection (ft^3/s)	Compositing technique and notes
Storm drain C (212353157533001)	01/28/2002 23:48	20	01/28/2002 20:57 to 01/29/2002 00:54	19	3.0–16	6.6	flow weighted
Xeriscape garden (16226200)	01/29/2002 00:28 and 01/29/2002 06:17	562 and 444	01/28/2002 22:40 to 01/29/2002 01:05	24	95–562	269	flow weighted
Quarantine station (16226400)	01/29/2002 00:35 and 01/29/2002 06:30	677 and 585[a]	01/28/2002 22:54 to 01/29/2002 01:18	24	139–625[a]	355[a]	flow weighted

[a]The stage-discharge relationship at the Quarantine station gaging station is not well defined at stage values greater than about 2.8 ft above the stage of zero flow, corresponding to a discharge of about 200 ft^3/s. These discharge values are estimates.

Table 18. Temperature, pH, and specific conductance field measurements for grab samples collected on January 29, 2002, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision
[°C, degrees Celsius; µS/cm, microsiemens per centimeter]

			Abbreviated station name and number				
Physical property	Unit	Reporting level	Bridge 8 (212356157531801)	Storm drain C (212353157533001)	Xeriscape garden (16226200)	Quarantine station (16226400)	Stadium (16227100)
Temperature	°C	nearest 0.5°C	20.0	22.5	20.0	21.0	21.5
pH	pH	nearest 0.1	7.3	6.4	7.6	7.8	7.7
Specific conductance	µS/cm	nearest whole number	124	314	175	173	229

Table 19. Concentrations and instantaneous loads of physical properties and constituents for grab samples collected from Halawa Stream drainage basin on January 29, 2002, Oahu, Hawaii

Data provisional--subject to revision.

[Conc., concentration; Instant. load, instantaneous load; na, not applicable; <, actual value is less than value shown; ≤, actual value is less than or equal to value shown; e, estimated value; mg/L, milligrams per liter; µg/L, micrograms per liter; MPN/100 mL, most probable number (of colonies) per 100 milliliters; loads reported as lbs/day, pounds per day]

Physical property or constituent	Concentration unit	Instantaneous load unit	Minimum reporting level for concentration[a]	Abbreviated station name and number									
				Bridge 8 (212356157531801)		Storm drain C (212353157533001)		Xeriscape garden (16226200)		Quarantine station (16226400)		Stadium (16227100)	
				Conc.	Instant. load[f]	Conc.	Instant. load[f]	Conc.	Instant. load[f]	Conc.	Instant. load[f]	Conc.	Instant. load[f]
Chemical oxygen demand	mg/L	lbs/day	10	11	5,200	<10	<53	12	7,600	18	16,000	12	19,000
Total suspended solids	mg/L	lbs/day	10	50	24,000	<10	<53	34	22,000	114	102,000	42	68,000
Total dissolved solids	mg/L	lbs/day	10	76	36,000	192	1,000	110	70,000	98	88,000	136	220,000
Nitrogen, total organic + ammonia[b]	mg/L	lbs/day	0.10	0.30	140	0.12	0.63	0.23	150	0.46	410	0.34	550
Ammonia, dissolved, as N[c]	mg/L	lbs/day	0.040	<0.040	<19	<0.040	<0.21	<0.040	<25	<0.040	<36	<0.040	<65
Nitrogen, nitrite, dissolved, as N[c]	mg/L	lbs/day	0.008	<0.008	<4	<0.008	<0.04	<0.008	<5	<0.008	<7	<0.008	<10
Nitrate + nitrite, dissolved, as N[c]	mg/L	lbs/day	0.050	0.113	54	0.550	2.9	0.211	134	0.241	216	0.559	905
Total nitrogen, as N[d]	mg/L	lbs/day	na	0.41	190	0.67	3.5	0.44	280	0.70	630	0.90	1,500
Organic nitrogen, as N[e]	mg/L	lbs/day	na	≤0.30	≤140	≤0.12	≤0.63	≤0.23	≤150	≤0.46	≤410	≤0.34	≤550
Total phosphorus, as P	mg/L	lbs/day	0.060	0.077	37	e0.031	e0.16	e0.051	e32	0.197	176	0.072	120
Dissolved phosphorous, as P	mg/L	lbs/day	0.060	<0.060	<28	e0.032	e0.17	<0.060	<38	<0.060	<54	<0.060	<97
Total cadmium	µg/L	lbs/day	0.04	<0.04	<0.02	0.04	0.0002	<0.04	<0.03	e0.03	e0.03	<0.04	<0.06
Total copper	µg/L	lbs/day	0.6	4.9	2.3	1.9	0.010	3.9	2.5	10.3	9.22	5.0	8.1
Total lead	µg/L	lbs/day	1	<1	<0.5	<1	<0.005	<1	<0.6	<1	<0.9	<1	<2
Total zinc	µg/L	lbs/day	1	7	3	13	0.069	11	7.0	13	12	6	10
Oil and grease	mg/L	lbs/day	7	<7	<3,000	<7	<40	<7	<4,000	<7	<6,000	<7	<10,000
Total petroleum hydrocarbons	mg/L	lbs/day	2	2	900	<2	<10	<2	<1,000	<2	<2,000	2	3,000
Biologic oxygen demand	mg/L	lbs/day	1	<1	<500	<1	<5	<1	<600	1	900	1	2,000
Fecal coliform	MPN/100mL	billion colonies per day	2	300	600	500	10	500	1,000	800	3,000	300	2,000

[a] Minimum reporting levels are based on values published by the USGS National Water Quality Laboratory.

[b] Nitrogen, total organic + ammonia is total Kjeldahl nitrogen.

[c] Ammonia, nitrite, and nitrate + nitrite are analyzed from filtrate. In January 1993, USGS National Water Quality Laboratory analyses for total ammonia, total nitrite, and total nitrate + nitrite were discontinued and only dissolved ammonia, dissolved nitrite, and dissolved nitrate + nitrite were analyzed after that date. Values for the total and for the dissolved constituents were statistically indistinguishable (U.S. Geological Survey Office of Water Quality Technical Memorandum 93.04). USGS National Water Quality Laboratory methods for these constituents are different from USEPA methods; however, USGS methods have similar or more accurate results.

[d] Total nitrogen is calculated by adding nitrogen, total organic + ammonia (Kjeldahl) to nitrate + nitrite, dissolved.

[e] Organic nitrogen is calculated by subtracting ammonia, dissolved, from nitrogen, total organic + ammonia (Kjeldahl). If the concentration value of ammonia, dissolved is below the minimum reporting level, the concentration value for organic nitrogen is reported as less than or equal to the value of total organic + ammonia (Kjeldahl), which represents the maximum possible value for organic nitrogen.

[f] Instantaneous load is computed from the concentration value and the discharge at the mean time of sample collection.

Table 20. Concentrations and average loads of physical properties and constituents for composite samples collected from Halawa Stream drainage basin on January 29, 2002, Oahu, Hawaii.

Data provisional--subject to revision.

[Conc., concentration; na, not applicable; <, actual value is less than value shown; ≤, actual value is less than or equal to value shown; mg/L, milligrams per liter; µg/L, micrograms per liter; loads reported as lbs/day, pounds per day]

Physical property or constituent	Concentration unit	Composite sample average load unit	Minimum reporting level for concentration[a]	Abbreviated station name and number					
				Storm drain C (212353157533001)		Xeriscape garden (16226200)		Quarantine station (16226400)	
				Conc.	Average load[f]	Conc.	Average load[f]	Conc.	Average load[f]
Chemical oxygen demand	mg/L	lbs/day	10	<10	<360	160	230,000	130	250,000
Total suspended solids	mg/L	lbs/day	10	<10	<360	1,160	1,680,000	1,140	2,180,000
Total dissolved solids	mg/L	lbs/day	10	20	710	46	67,000	50	96,000
Nitrogen, total organic + ammonia[b]	mg/L	lbs/day	0.10	0.12	4.3	4.0	6,000	3.7	7,100
Ammonia, dissolved, as N[c]	mg/L	lbs/day	0.040	<0.040	<1.4	<0.040	<58	<0.040	<77
Nitrogen, nitrite, dissolved, as N[c]	mg/L	lbs/day	0.008	<0.008	<0.3	<0.008	<10	<0.008	<20
Nitrate + nitrite, dissolved, as N[c]	mg/L	lbs/day	0.050	<0.050	<1.8	0.075	110	0.090	170
Total nitrogen, as N[d]	mg/L	lbs/day	na	<0.17	<6.1	4.1	5,900	3.8	7,300
Organic nitrogen, as N[e]	mg/L	lbs/day	na	≤0.12	≤4.3	≤4.0	≤5,800	≤3.7	≤7,100
Total phosphorus, as P	mg/L	lbs/day	0.060	<0.060	<2.1	1.22	1,770	1.22	2,340
Dissolved phosphorous, as P	mg/L	lbs/day	0.060	<0.060	<2.1	<0.060	<87	<0.060	<110
Total cadmium	µg/L	lbs/day	0.04	0.05	0.002	0.19	0.28	0.20	0.38
Total copper	µg/L	lbs/day	0.6	5.6	0.20	59.4	86.1	60.2	115
Total lead	µg/L	lbs/day	1	2	0.07	5	7	6	10
Total zinc	µg/L	lbs/day	1	21	0.75	74	110	79	150

[a] Minimum reporting levels are based on values published by the USGS National Water Quality Laboratory.

[b] Nitrogen, total organic + ammonia is total Kjeldahl nitrogen.

[c] Ammonia, nitrite, and nitrate + nitrite are analyzed from filtrate. In January 1993, USGS National Water Quality Laboratory analyses for total ammonia, total nitrite, and total nitrate + nitrite were discontinued and only dissolved ammonia, dissolved nitrite, and dissolved nitrate + nitrite were analyzed after that date. Values for the total and for the dissolved constituents were statistically indistinguishable (U.S. Geological Survey Office of Water Quality Technical Memorandum 93.04). USGS National Water Quality Laboratory methods for these constituents are different from USEPA methods; however, USGS methods have similar or more accurate results.

[d] Total nitrogen is calculated by adding nitrogen, total organic + ammonia (Kjeldahl) to nitrate + nitrite, dissolved. If the concentration value of nitrate + nitrite, dissolved is below the minimum reporting level, the concentration value of total nitrogen is reported as less than the sum of the values shown for nitrogen, total organic + ammonia and nitrate + nitrite, dissolved, which represents the maximum possible value for total nitrogen.

[e] Organic nitrogen is calculated by subtracting ammonia, dissolved, from nitrogen, total organic + ammonia (Kjeldahl). If the concentration value of ammonia, dissolved is below the minimum reporting level, the concentration value for organic nitrogen is reported as less than or equal to the value of total organic + ammonia (Kjeldahl). If both concentration values of nitrogen, total organic + ammonia (Kjeldahl) and ammonia, dissolved are below the minimum reporting level, the concentration value for organic nitrogen is reported as less than the value of total organic + ammonia (Kjeldahl). In both cases, the concentration value represents the maximum possible value for organic nitrogen.

[f] Average load is computed from the concentration value and the average discharge during sample collection.

Storm of April 20, 2002

Hydrologic Conditions During Sampling and Data Collection

Rainfall in the late afternoon of April 20, 2002 resulted in a quick rise and fall of North Halawa Stream. The rainfall provided only enough discharge to briefly trigger the automatic samplers at the Storm drain C, Xeriscape garden, and Quarantine station sites. Samples from the automatic samplers were used for grab and composite samples.

Hydrographs of streamflow at Storm drain C, Xeriscape garden, and Quarantine station during April 20, 2002 storm are shown in figures 14, 15, and 16, respectively. The times of peak flow, and the times of grab-sample collection from the automatic sampler and corresponding discharges at the times of sample collection, are listed in table 21. The number of samples collected by the automatic samplers and used for the composite samples, the beginning and end times of sample collection by the automatic samplers, and the average discharges during the collection of the composite samples are shown in table 22. Sample-collection times also are displayed in the hydrographs (figs. 14, 15, and 16).

Sampling and Discharge Measurement Methods

Manual grab samples were not collected for this event due to the timing and extent of the runoff; the rise of the stream occurred too late in the day (on a Sunday) to mobilize and collect samples, and by the morning of the following day, the stage of the stream had diminished substantially.

At the Storm drain C, Xeriscape garden, and Quarantine station gaging stations, only 8 or fewer samples were collected by the automatic samplers. The samples were processed either individually as a grab sample, or flow-weighted and combined as a composite sample. No field measurements were made. No qa/qc samples were collected during this storm due to the limited volume of sample collected by the automatic samplers.

Storm drain C.--Eight samples were collected by the automatic sampler. To determine possible differences in concentration through time, each sample was analyzed individually. Discharge was determined using the stage at the time of sample collection by the automatic sampler and the stage-discharge rating for this gage.

Xeriscape garden.--Five samples were collected by the automatic sampler. A flow-weighted composite sample was created using all five samples. Discharge was determined using the stage at the time of sample collection by the automatic sampler and the stage-discharge rating for this gage.

Quarantine station.--Seven samples were collected by the automatic sampler. A flow-weighted composite sample was created with the first five samples. The last two samples, which were separated by 12 minutes from the first five, were analyzed individually as grab samples. Discharge was determined using the stage at the time of sample collection by the automatic sampler and the stage-discharge rating for this gage.

Analytical Results and Loads

The samples were analyzed for metals only. Temperature, pH, and specific-conductance were not measured for this sample. Table 23 shows concentrations, instantaneous loads, and average loads of total cadmium, total copper, total lead, and total zinc for the 10 grab samples and 2 composite samples.

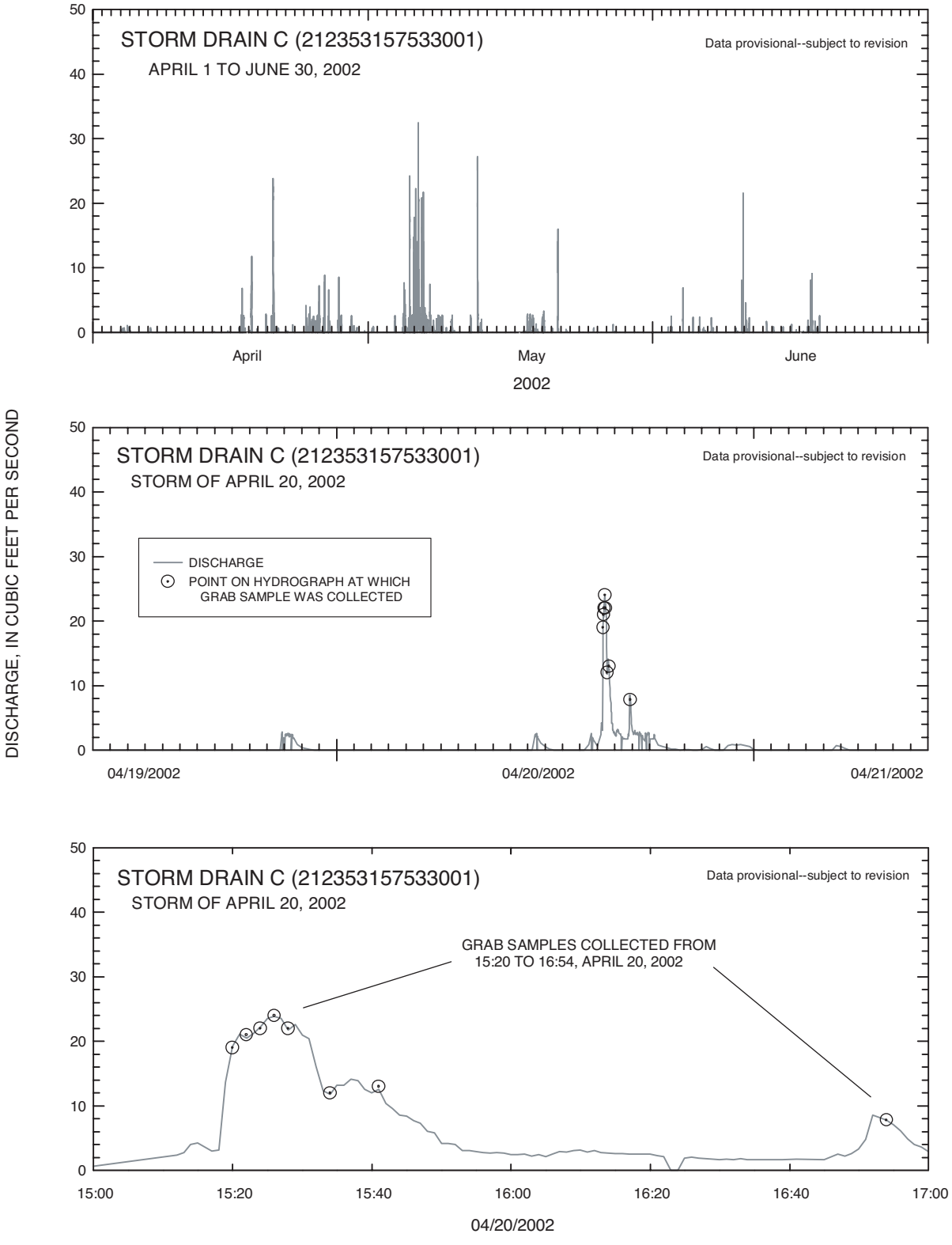

Figure 14. Stream discharge at Storm drain C gaging station (212353157533001) for April 1 to June 30, 2002; detail for the 2-day period from 10:00 April 19, 2002 to 10:00 April 21, 2002; and detail for the 2-hour period from 15:00 to 17:00, April 20, 2002, Oahu, Hawaii.

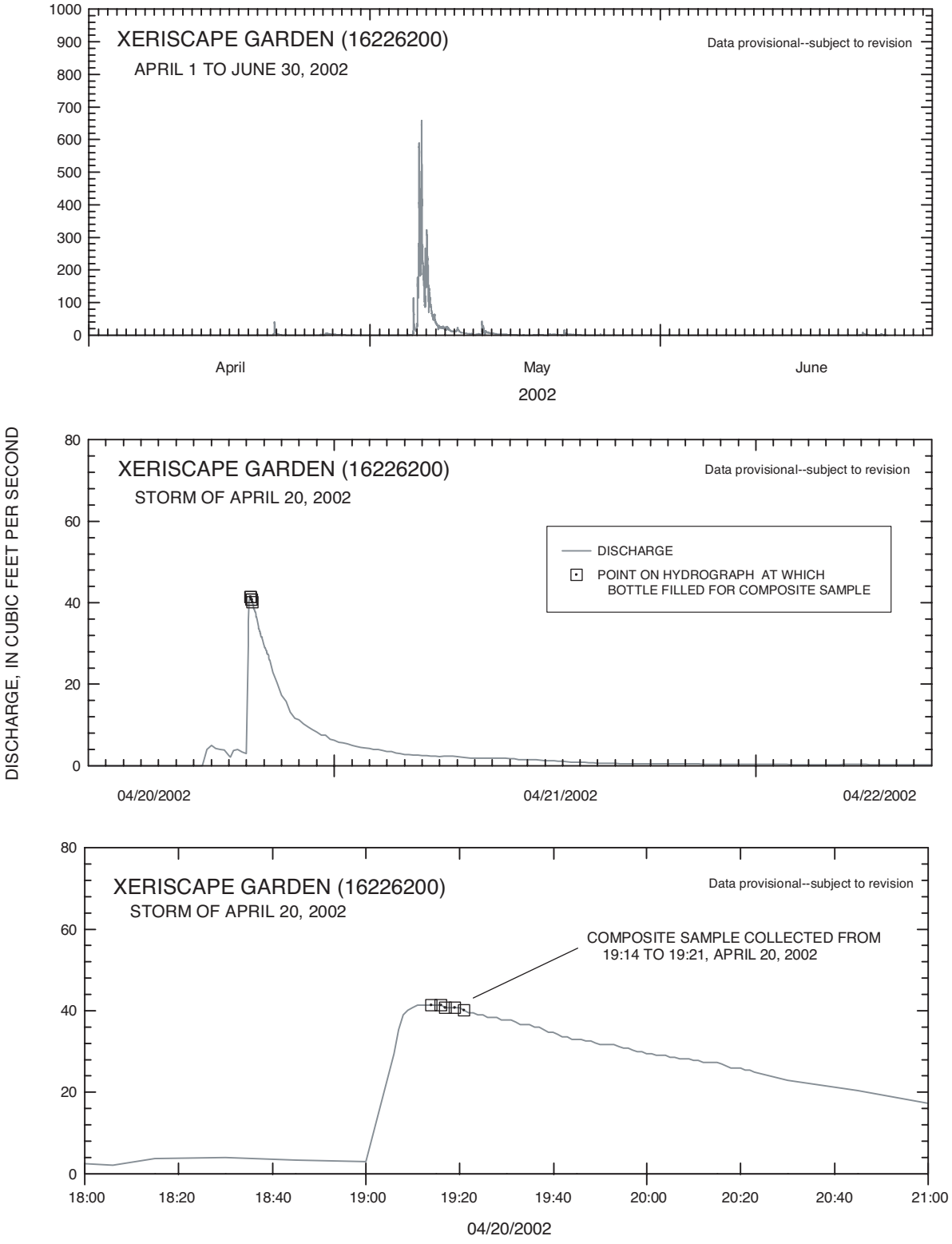

Figure 15. Stream discharge at Xeriscape garden gaging station (16226200) for April 1 to June 30, 2002; detail for the 2-day period from 10:00 April 20, 2002 to 10:00 April 22, 2002; and detail for the 3-hour period from 18:00 to 21:00, April 20, 2002, Oahu, Hawaii.

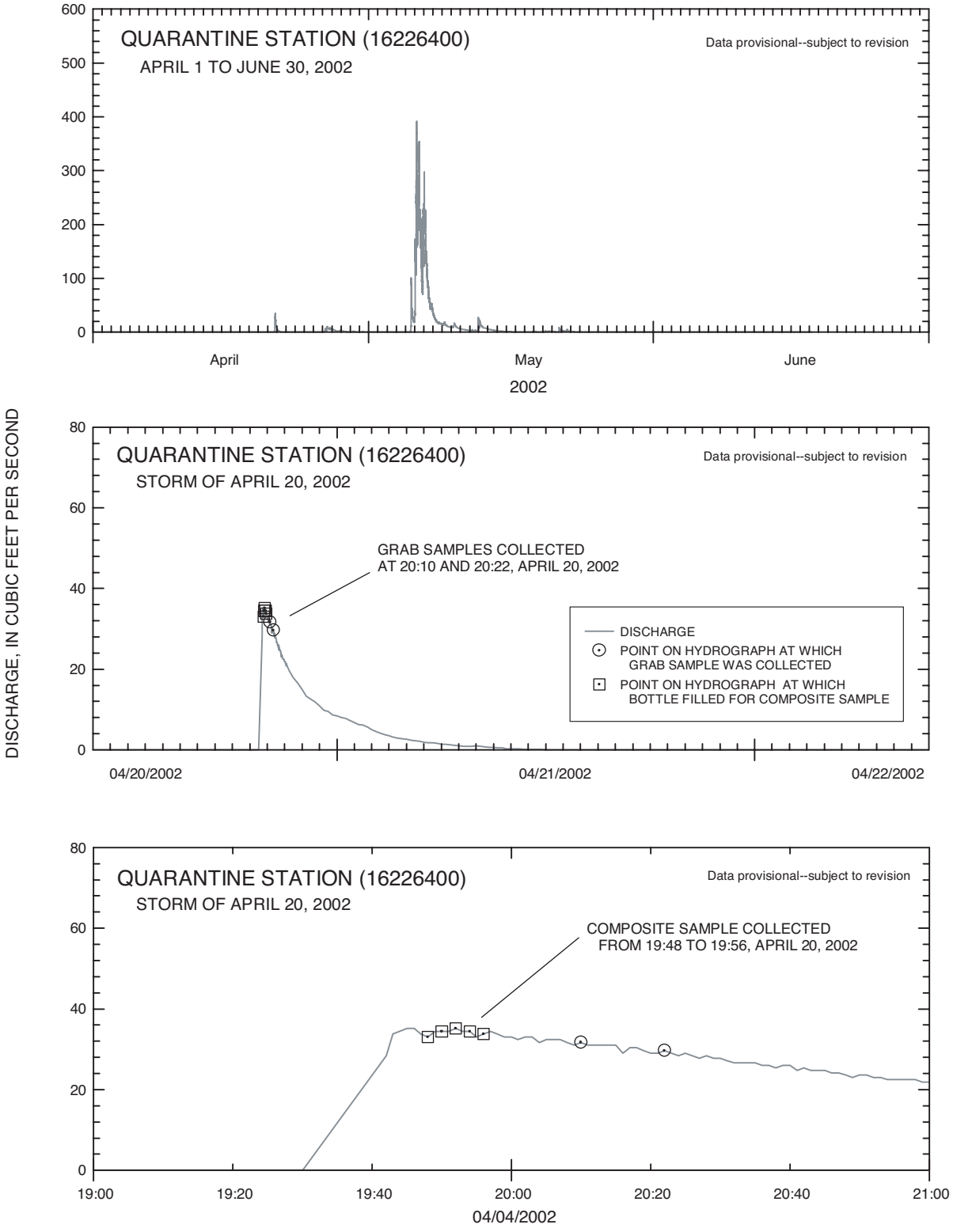

Figure 16. Stream discharge at Quarantine station gaging station (16226400) for April 1 to June 30, 2002; detail for the 2-day period from 10:00 April 20, 2002 to 10:00 April 22, 2002; and detail for the 2-hour period from 19:00 to 21:00, April 20, 2002, Oahu, Hawaii.

Table 21. Hydrologic conditions during grab-sample collection, April 20, 2002, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision
[ft^3/s, cubic feet per second]

Abbreviated station name and station number	Date and time of peak discharge	Peak stage (feet over stage of zero flow)	Peak discharge (ft^3/s)	Date and time of grab- sample collection	Stage at time of grab-sample collection, (feet above stage of zero flow)	Discharge at time of grab-sample collection, (ft^3/s)
Storm drain C (212353157533001)	04/20/2002 15:26	2.43	24	04/20/2002 15:20	2.05	19
				04/20/2002 15:22	2.16	21
				04/20/2002 15:24	2.30	22
				04/20/2002 15:26	2.43	24
				04/20/2002 15:28	2.26	22
				04/20/2002 15:34	1.41	12
				04/20/2002 15:41	1.48	13
				04/20/2002 16:54	1.02	7.8
Quarantine station (16226400)	04/20/2002 19:45	1.58	35	04/20/2002 20:10	1.53	32
				04/20/2002 20:22	1.50	30

Table 22. Hydrologic conditions and sampling data during composite-sample collection, April 20, 2002, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision
[ft^3/s, cubic feet per second]

Abbreviated station name and station number	Date and time of peak discharge	Peak discharge (ft^3/s)	Beginning and ending dates and times of automatic- sample collection	Number of samples used for composite sample	Range of discharge at times of sample collection (ft^3/s)	Average discharge during sample collection (ft^3/s)	Compositing technique and notes
Xeriscape garden (16226200)	04/20/2002 19:11	41	04/20/2002 19:14 to 04/20/2002 19:21	5	40–41	41	flow weighted
Quarantine station (16226400)	04/20/2002 19:45	35	04/20/2002 19:48 to 04/20/2002 19:56	5	33–35	34	flow weighted

Table 23. Concentrations, instantaneous loads, and average loads of total metals for samples collected from Halawa Stream drainage basin on April 20, 2002, Oahu, Hawaii

Data provisional--subject to revision

[ft^3/s, cubic feet per second; conc., concentration; concentrations are reported as µg/L, micrograms per liter; loads reported as lbs/day, pounds per day; instant., instantaneous; <, actual value is less than value shown]

Station name, number, and time of collection	Discharge at time of collection[b] (ft^3/s)	Type of sample	Type of load[c]	Metal analysis[a]							
				Total cadmium		Total copper		Total lead		Total zinc	
				Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load
Storm drain C (212353157533001)											
15:20	19	grab	instant.	0.26	0.027	21.2	2.2	6	0.6	74	7.6
15:22	21	grab	instant.	0.14	0.016	17.9	2.0	5	0.6	57	6.5
15:24	22	grab	instant.	0.12	0.014	12.6	1.5	4	0.5	42	5.0
15:26	24	grab	instant.	0.06	0.008	7.4	0.96	2	0.3	27	3.5
15:28	22	grab	instant.	0.08	0.01	9.9	1.2	3	0.4	34	4.0
15:34	12	grab	instant.	0.06	0.004	5.4	0.35	1	0.06	22	1.4
15:41	13	grab	instant.	0.07	0.005	5.6	0.39	1	0.07	26	1.8
16:54	7.8	grab	instant.	0.05	0.002	5.9	0.25	<1	<0.04	20	0.84
Xeriscape garden (16226200)											
19:14 to 19:21	41	composite	average	0.07	0.02	11.1	2.5	3	0.7	37	8.2
Quarantine station (16226400)											
19:48 to 19:56	34	composite	average	0.24	0.044	53.6	9.8	9	2	102	19
20:10	32	grab	instant.	0.07	0.01	16.9	2.9	2	0.3	28	4.8
20:22	30	grab	instant.	0.04	0.007	12.2	2.0	2	0.3	18	2.9

[a] Minimum reporting levels for cadmium, copper, lead and zinc are 0.04, 0.6, 1 and 1 mg/L, respectively. Minimum reporting levels are based on values published by the USGS National Water Quality Laboratory.

[b] Discharges are either instantaneous for grab samples or time-averaged for composite samples.

[c] Loads are reported either as instantaneous loads for grab samples, computed using the instantaneous discharges, or as average loads for composite samples, computed using the time-averaged discharges.

Storm of May 5-6, 2002

Hydrologic Conditions During Sampling and Data Collection

Hydrographs of streamflow at Storm drain C, Xeriscape garden, and Quarantine station during the storm of May 5–6, 2002 are shown in figures 17, 18 and 19, respectively. Two discharge peaks occurred about 7 hours apart at the at the Xeriscape garden and Quarantine station sites. Discharge was high during this storm, reaching about 659 and 454 ft^3/s at the Xeriscape garden and Quarantine station sites, respectively. The hydrograph for the Quarantine station also shows estimated discharge based on the discharge from the Xeriscape garden gage. As mentioned before, the stage-discharge rating for the Quarantine station gaging station was not well defined at discharges above 200 to 300 ft^3/s because of the limited data from this recently established gage.These two sites are about 5,000 ft apart. It is likely that the discharge was similar at these two sites during this storm.

The times of peak flow, and the times of grab-sample collection and corresponding discharges at the times of sample collection, are listed in table 24. The number of samples collected by the automatic samplers and used for the composite samples, the beginning and end times of sample collection by the automatic samplers, and the average discharges during the collection of the composite samples are shown in table 25. Sample-collection times also are displayed in the hydrographs (figs. 17, 18, and 19).

Sampling and Discharge Measurement Methods

Grab samples were collected at all five sites during the storm on May 5–6, 2002. Composite samples were collected at the Storm drain C, Xeriscape garden, and Quarantine station sites.

Bridge 8.--A grab sample was collected along a single vertical line at the estimated fastest and deepest section of the stream. Discharge was concentrated in the middle six feet of the stream cross section. An isokinetic sampler attached to an aluminum pole was used to collect the sample. A field duplicate was collected at this site. Discharge associated with the grab sample was determined using the stage at the mean time of grab-sample collection and the stage-discharge rating for this gage.

Storm drain C.--A grab sample was collected at the centroid of flow by directly submersing the HDPE churn. Temperature was not measured at this site during this storm. Discharge associated with the grab sample was determined using the stage at the mean time of grab-sample collection and the stage-discharge rating for this gage.

A flow-weighted, time-composite sample was created by combining four samples from the automatic sampler. The samples were collected over a 30-minute period (fig. 17).

Xeriscape garden.--A grab sample was collected along a single vertical line at the estimated fastest and deepest section of the stream. An isokinetic sampler was used to collect the sample. Discharge was concentrated in the middle of the stream cross section. A laboratory spike sample also was collected at this site. Temperature was not measured at this site during this storm. Discharge associated with the grab sample was determined using the stage at the mean time of grab-sample collection and the stage-discharge rating for this gage.

A flow-weighted, time-composite sample was created by combining 11 samples from the automatic sampler. The samples were collected during the initial rise of the stream (fig. 18). All but one of the samples were flow weighted; the one sample that was not flow-weighted did not have sufficient volume to properly flow-weight, thus the entire contents of this sample was used for the composite.

Quarantine station.--A grab sample was collected about 300 ft downstream from the gage at an abandoned roadway bridge. The sample was collected along a single vertical line at the estimated fastest and deepest section of the stream. The stream was well mixed. Stream width was about 37 ft. An isokinetic sampler connected to an aluminum pole was used to collect the sample. Sample water from this site also was used for a laboratory duplicate. Discharge associated with the grab sample was determined using the stage at the mean time of grab-sample collection and the stage-discharge rating for this gage.

A flow-weighted, time-composite sample was created by combining 20 samples from the automatic sampler.The samples were collected during the initial rise of the stream (fig. 19). All but one of the samples were flow weighted; the one sample that was not flow-weighted did not have sufficient volume to properly

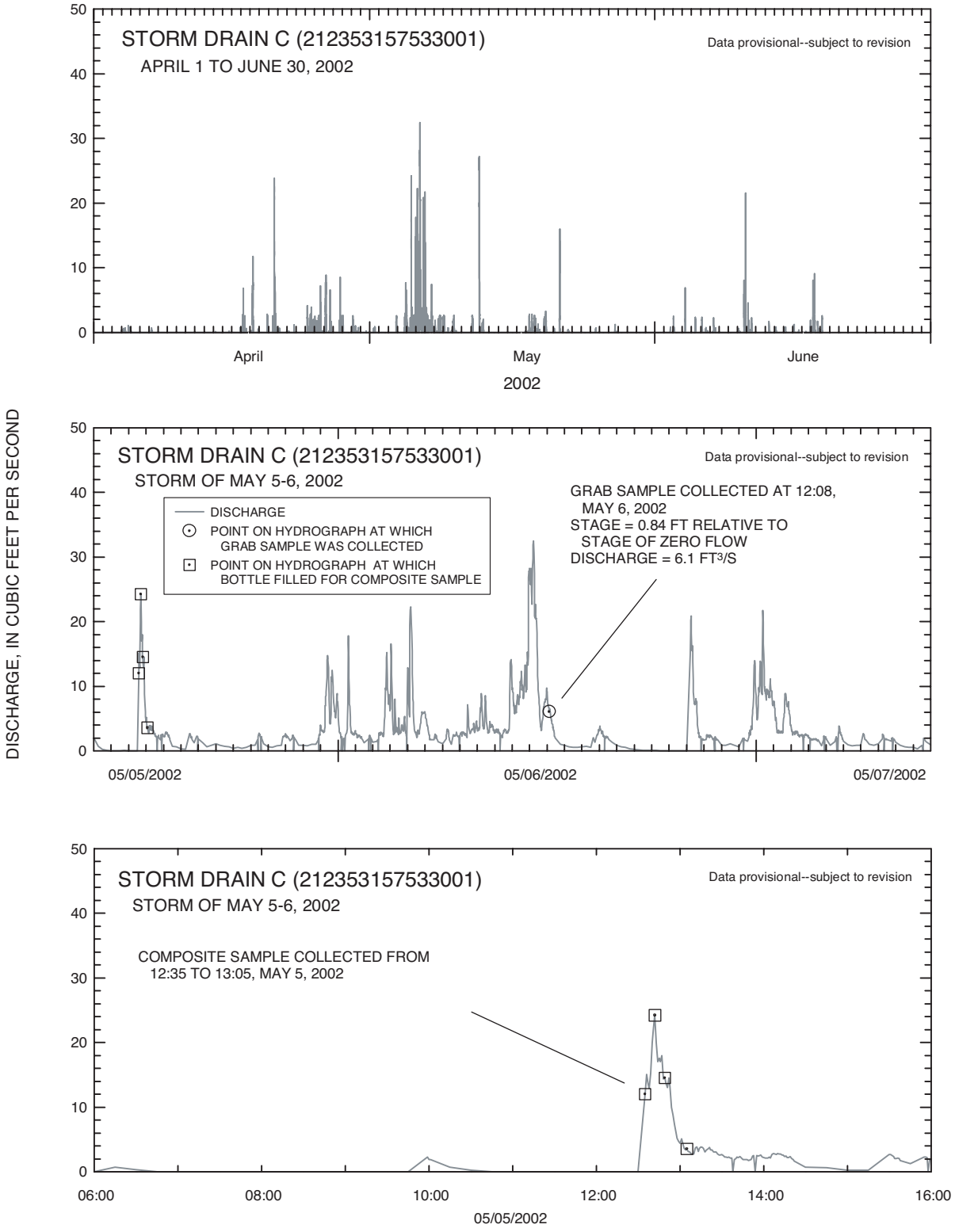

Figure 17. Stream discharge at Storm drain C gaging station (212353157533001) for April 1 to June 30, 2002; detail for the 2-day period from 10:00 May 5, 2002 to 10:00 May 7, 2002; and detail for the 10-hour period from 06:00 to 16:00, May 5, 2002, Oahu, Hawaii.

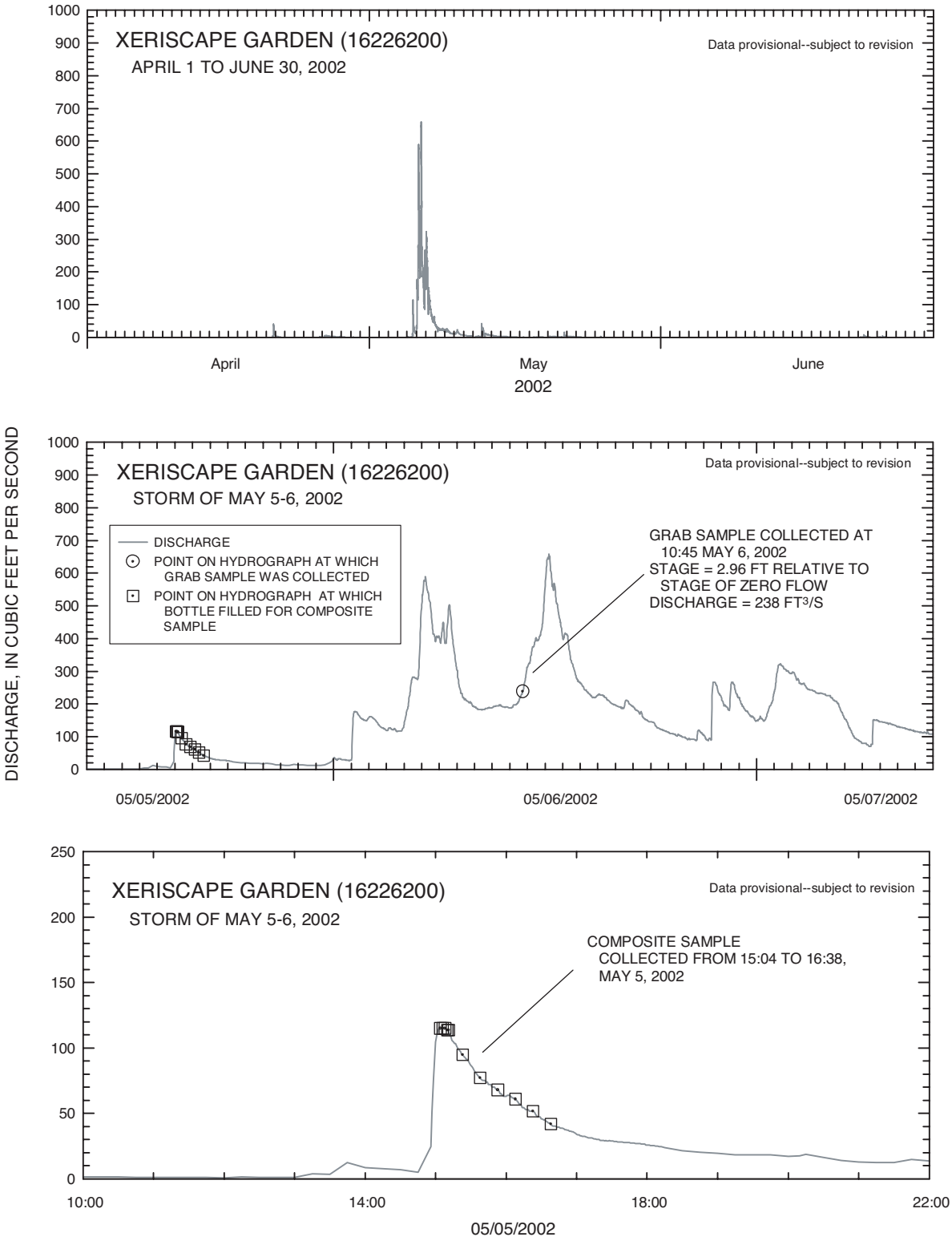

Figure 18. Stream discharge at Xeriscape garden gaging station (16226200) for April 1 to June 30, 2002; detail for the 2-day period from 10:00 May 5, 2002 to 10:00 May 7, 2002; and detail for the 12-hour period from 10:00 to 22:00, May 5, 2002, Oahu, Hawaii.

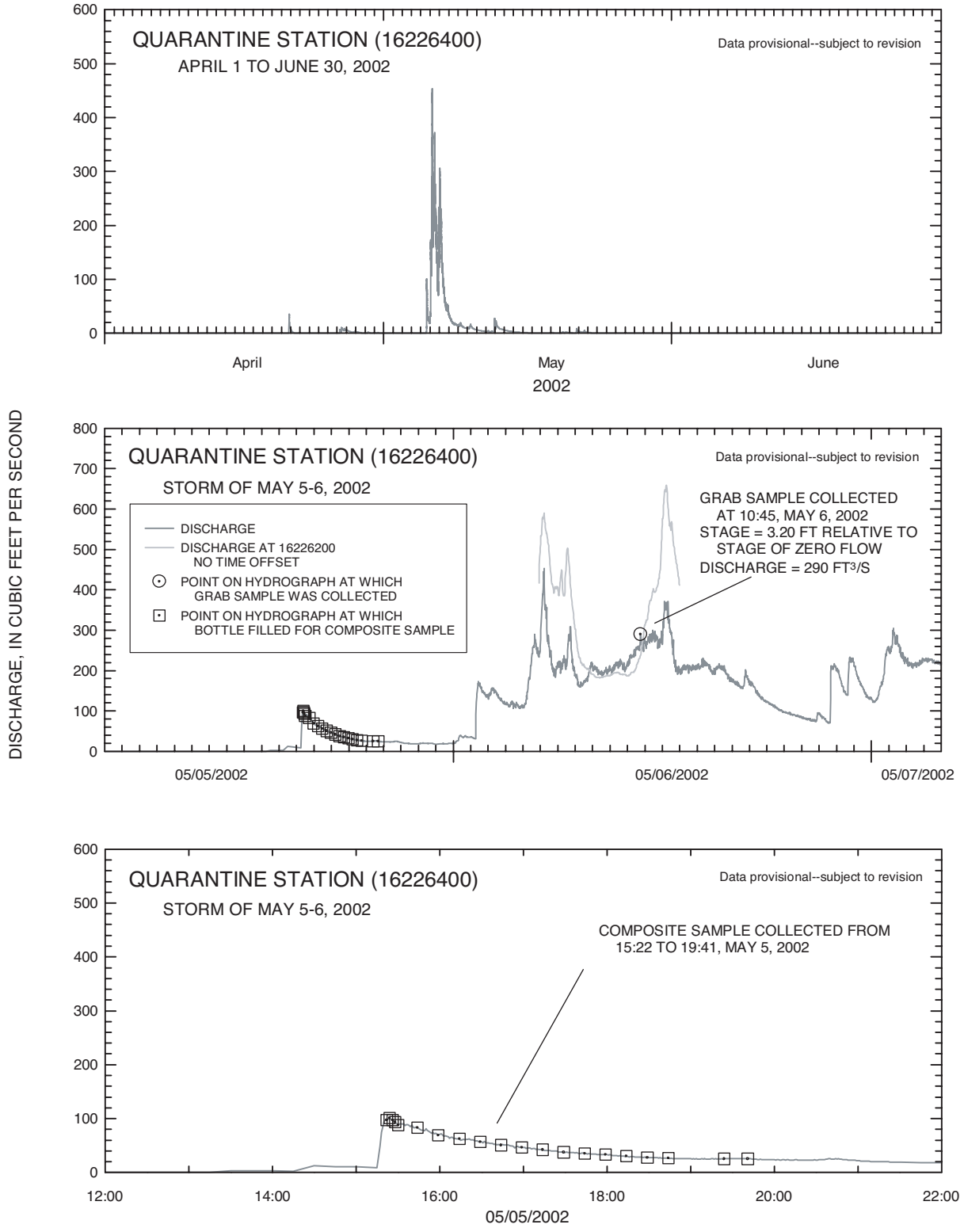

Figure 19. Stream discharge at Quarantine station gaging station (16226400) for April 1 to June 30, 2002; detail for the 2-day period from 10:00 May 5, 2002 to 10:00 May 7, 2002; and detail for the 10-hour period from 12:00 to 22:00, May 5, 2002, Oahu, Hawaii.

Table 24. Hydrologic conditions during grab-sample collection, May 6, 2002, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision.
[--, no data; ft^3/s, cubic feet per second]

Abbreviated station name and station number	Date and time of peak discharge	Peak stage (feet over stage of zero flow)	Peak discharge (ft^3/s)	Date and time of grab- sample collection	Stage at time of grab- sample collection (feet above stage of zero flow)	Discharge at time of grab-sample collection (ft^3/s)
Bridge 8 (212356157531801)	--	--	--	05/06/2002 12:30	3.33	297
Storm drain C (212353157533001)	05/05/2002 12:42 and 05/06/2002 11:13	2.46 and 3.07	24 and 32	05/06/2002 12:08	0.84	6.1
Xeriscape garden (16226200)	05/06/2002 05:13 and 05/06/2002 12:14	4.21 and 4.39	591 and 659	05/06/2002 10:45	2.96	238
Quarantine station (16226400)	05/06/2002 05:13 and 05/06/2002 12:08	3.73 and 3.48	454 and 372[a]	05/06/2002 10:45	3.20	290[a]
Stadium (16227100)	--	--	--	05/06/2002 13:11	1.48	870

[a]The stage-discharge relationship at the Quarantine station gaging station is not well defined at stage values greater than about 2.8 ft above the stage of zero flow, corresponding to a discharge of about 200 ft^3/s. These discharge values are estimates.

Table 25. Hydrologic conditions and sampling data during composite-sample collection, May 5–6, 2002, Halawa Stream drainage basin, Oahu, Hawaii
Data provisional--subject to revision.
[ft^3/s, cubic feet per second]

Abbreviated station name and station number	Date and time of peak discharge	Peak discharge (ft^3/s)	Beginning and ending dates and times of automatic-sample collection	Number of samples used for composite sample	Range of discharge at times of sample collection (ft^3/s)	Average discharge during sample collection (ft^3/s)	Compositing technique and notes
Storm drain C (212353157533001)	05/05/2002 12:42 and 05/06/2002 11:13	24 and 32	05/05/2002 12:35 to 05/05/2002 13:05	4	3.6–24	11	not flow weighted
Xeriscape garden (16226200)	05/06/2002 05:13 and 05/06/2002 12:14	591 and 659	05/05/2002 15:04 to 05/05/2002 16:38	11	42–115	69	flow weighted except for one bottle
Quarantine station (16226400)	05/06/2002 05:13 and 05/06/2002 12:08	454 and 372[a]	05/05/2002 15:22 to 05/05/2002 19:41	20	25–101	43	flow weighted except for one bottle

[a]The stage-discharge relationship at the Quarantine station gaging station is not well defined at stage values greater than about 2.8 ft above the stage of zero flow, corresponding to a discharge of about 200 ft^3/s. These discharge values are estimates.

flow-weight, thus the entire contents of this sample was used for the composite.

Stadium.--The grab sample was collected along a single vertical line at the estimated fastest and deepest section of the stream. The stream was well mixed. An isokinetic sampler attached to an aluminum pole was used to collect the sample. Discharge was measured by the float method.

Analytical Results and Loads

The samples were analyzed for all of the constituents listed in the Stormwater Monitoring Program Plan (State of Hawaii Department of Transportation, 2000). Table 26 shows temperature, pH, and specific-conductance for the 5 grab samples. Constituent concentrations and instantaneous loads for the five grab samples are shown in table 27, constituent concentrations and average loads for the three composite samples are shown in table 28.

QUALITY ASSURANCE

Field and laboratory quality-assurance and quality-control procedures were implemented as described in the DOT Storm Water Monitoring Program Plan (State of Hawaii Department of Transportation, 2000). Twenty two quality-assurance/quality-control (qa/qc) samples were collected: 12 samples were collected concurrently with storm samples during four of the storms, and 10 samples were collected between storms during routine cleaning of the sampling equipment.

During sampling of storm events, field duplicate samples, laboratory duplicate samples, and laboratory spike samples were prepared. Results from these analyses are available.

All grab-sample collection equipment was cleaned before each storm and sampling. The automatic-sampler intake line for Storm drain C was cleaned 9 times during the year. However, due to the discharge variability in Storm drain C, occasionally, the sampler was triggered and a few samples were collected during brief rain showers, contaminating the intake line prior to subsequent storms. The intake line was contaminated in this manner prior to the October 28, 2001 and the April 20, 2002 samples. Additionally, the automatic-sampler intake lines on the Storm drain C, Xeriscape, and Quarantine automatic samplers were not cleaned between the January 26–27 and January 28–29, 2002, samples.

With regard to potential contamination problems with the intake lines, it is important to note that the automatic sampler does pump a rinse cycle prior to every sample collected. Water is first purged, then sucked up the line to a sensor located before the sample bottles, then purged before the sample is collected. After the sample is collected, the line is purged again. The purge, rinse, purge, sample collection, and third-purge cycle minimizes possible contamination from water pumped during earlier storms and from previously pumped samples during the same storm.

Inorganic blank water rinsate samples were collected from the automatic samplers after cleaning the intake lines. Additionally, one rinsate sample was collected from an isokinetic sampler after cleaning, and one rinsate ample was collected from a prototype teflon bottle liner used in the automatic samplers. The rinsate blank samples were analyzed for nutrients, and for cadmium, copper, lead, and zinc.

Rinsate blank samples from the automatic samplers were collected at: Storm drain C on August 21, 2001, December 12, 2001, and March 26, 2002; Xeriscape garden on August 21, 2001, December 12, 2001, and March 27, 2002; and Quarantine station on January 7, 2002 and March 27, 2002. Zinc was detected

Table 26. Temperature, pH, and specific conductance field measurements for grab samples collected on May 6, 2002, Halawa Stream drainage basin, Oahu, Hawaii

[°C, degrees Celsius; µS/cm, microsiemens per centimeter]

			Abbreviated station name and number				
Physical property	Unit	Reporting level	Bridge 8 (212356157531801)	Storm drain C (212353157533001)	Xeriscape garden (16226200)	Quarantine station (16226400)	Stadium (16227100)
Temperature	°C	nearest 0.5°C	20.5	no measurement	no measurement	21.0	21.5
pH	pH	nearest 0.1	6.4	7.1	7.4	7.8	7.4
Specific conductance	µS/cm	nearest whole number	75	44	74	68	70

Table 27. Concentrations and instantaneous loads of physical properties and constituents for grab samples collected from Halawa Stream drainage basin on May 6, 2002, Oahu, Hawaii. Data provisional--subject to revision.

[Conc., concentration; Instant. load, instantaneous load; na, not applicable; <, actual value is less than value shown; ≤, actual value is less than or equal to value shown; mg/L, milligrams per liter; µg/L, micrograms per liter; MPN/100 mL, most probable number (of colonies) per 100 milliliters; loads reported as lbs/day, pounds per day]

Physical property or constituent	Concentration unit	Instantaneous load unit	Minimum reporting level for concentration[a]	Abbreviated station name and number									
				Bridge 8 (212356157531801)		Storm drain C (212353157533001)		Xeriscape garden (16226200)		Quarantine station (16226400)		Stadium (16227100)	
				Conc.	Instant. load[f]	Conc.	Instant. load[f]	Conc.	Instant. load[f]	Conc.	Instant. load[f]	Conc.	Instant. load[f]
Chemical oxygen demand	mg/L	lbs/day	10	40	64,000	12	390	26	33,000	23	36,000	150	700,000
Total suspended solids	mg/L	lbs/day	10	557	892,000	<10	<330	440	560,000	310	480,000	1,540	7,230,000
Total dissolved solids	mg/L	lbs/day	10	43	69,000	19	630	39	50,000	43	67,000	44	210,000
Nitrogen, total organic + ammonia[b]	mg/L	lbs/day	0.10	1.4	2,200	0.18	5.9	0.77	990	0.84	1,300	4.5	21,000
Ammonia, dissolved, as N[c]	mg/L	lbs/day	0.040	<0.040	<64	<0.040	<1.3	<0.040	<51	<0.040	<63	<0.040	<190
Nitrogen, nitrite, dissolved, as N[c]	mg/L	lbs/day	0.008	<0.008	<10	e0.004	e0.13	<0.008	<10	<0.008	<10	<0.008	<40
Nitrate + nitrite, dissolved, as N[c]	mg/L	lbs/day	0.050	0.064	100	e0.045	e1.5	0.061	78	0.070	110	0.084	390
Total nitrogen, as N[d]	mg/L	lbs/day	na	1.5	2,400	e0.23	e7.6	0.83	1,100	0.91	1,400	4.6	22,000
Organic nitrogen, as N[e]	mg/L	lbs/day	na	≤1.4	≤2,200	≤0.18	≤5.9	≤0.77	≤990	≤0.84	≤1,300	≤4.5	≤21,000
Total phosphorus, as P	mg/L	lbs/day	0.060	0.670	1,070	e0.044	e1.4	0.502	644	0.471	737	1.56	7,320
Dissolved phosphorous, as P	mg/L	lbs/day	0.060	<0.060	<96	<0.060	<2.0	<0.060	<77	<0.060	<94	<0.060	<280
Total cadmium	µg/L	lbs/day	0.04	0.11	0.18	0.13	0.0043	0.15	0.19	0.10	0.16	0.30	1.4
Total copper	µg/L	lbs/day	0.6	32.7	52.4	13.3	0.44	39.1	50.2	24.2	37.9	73.8	346
Total lead	µg/L	lbs/day	1	2	3	4	0.1	3	4	3	5	9	40
Total zinc	µg/L	lbs/day	1	41	66	59	1.9	61	78	39	61	104	488
Oil and grease	mg/L	lbs/day	7	<7	<10,000	<7	<200	<7	<9,000	<7	<10,000	<7	<30,000
Total petroleum hydrocarbons	mg/L	lbs/day	2	<2	<3,000	<2	<70	<2	<3,000	<2	<3,000	<2	<9,000
Biologic oxygen demand	mg/L	lbs/day	1	2	3,000	2	70	2	3,000	4	6,000	2	9,000
Fecal coliform	MPN/100mL	billion colonies per day	2	1,300	9,400	5,000	700	3,000	20,000	9,000	60,000	9,000	200,000

[a] Minimum reporting levels are based on values published by the USGS National Water Quality Laboratory.

[b] Nitrogen, total organic + ammonia is total Kjeldahl nitrogen.

[c] Ammonia, nitrite, and nitrate + nitrite are analyzed from filtrate. In January 1993, USGS National Water Quality Laboratory analyses for total ammonia, total nitrite, and total nitrate + nitrite were discontinued and only dissolved ammonia, dissolved nitrite, and dissolved nitrate + nitrite were analyzed after that date. Values for the total and for the dissolved constituents were statistically indistinguishable (U.S. Geological Survey Office of Water Quality Technical Memorandum 93.04). USGS National Water Quality Laboratory methods for these constituents are different from USEPA methods; however, USGS methods have similar or more accurate results.

[d] Total nitrogen is calculated by adding nitrogen, total organic + ammonia (Kjeldahl) to nitrate + nitrite, dissolved. If the concentration value of nitrate + nitrite, dissolved is estimated and below the minimum reporting level, the concentration value of total nitrogen is reported as the sum of the values shown for nitrogen, total organic + ammonia and nitrate + nitrite, dissolved, and noted as estimated.

[e] Organic nitrogen is calculated by subtracting ammonia, dissolved, from nitrogen, total organic + ammonia (Kjeldahl). If the concentration value of ammonia, dissolved is below the minimum reporting level, the concentration value for organic nitrogen is reported as less than or equal to the value of total organic + ammonia (Kjeldahl), which represents the maximum possible value for organic nitrogen.

[f] Instantaneous load is computed from the concentration value and the discharge at the mean time of sample collection.

in all of the rinsate samples collected at the three stations. Concentrations of zinc ranged from 3 to 21 µg/L. The minimum reporting level of zinc is 1 µg/L. Nitrogen as ammonia, and nitrogen, total organic and ammonia, were detected at the Quarantine station for the March 27, 2002 rinsate blank sample. The concentration of the nitrogen as ammonia, and nitrogen, total organic and ammonia were 0.4 and 0.9 mg/L, respectively. The minimum reporting level for nitrogen as ammonia, and nitrogen, total organic and ammonia, are 0.040 and 0.10 mg/L, respectively. For the rinsate blank samples from the isokinetic sampler and the teflon bag, none of the inorganic analyses showed detections.

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Table 28. Concentrations and average loads of physical properties and constituents for composite samples collected from Halawa Stream drainage basin on May 6, 2002, Oahu, Hawaii.

Data provisional--subject to revision.

[Conc., concentration; na, not applicable; --, no data; <, actual value is less than value shown; ≤, actual value is less than or equal to value shown; e, estimated value; mg/L, milligrams per liter; µg/L, micrograms per liter; loads reported as lbs/day, pounds per day]

Physical property or constituent	Concentration unit	Composite sample average load unit	Minimum reporting level of concentration[a]	Abbreviated station name and number					
				Storm drain C (212353157533001)		Xeriscape garden (16226200)		Quarantine station (16226400)	
				Conc.	Average load[f]	Conc.	Average load[f]	Conc.	Average load[f]
Chemical oxygen demand	mg/L	lbs/day	10	32	1,900	61	23,000	--	--
Total suspended solids	mg/L	lbs/day	10	103	6,100	227	84,000	188	44,000
Total dissolved solids	mg/L	lbs/day	10	16	950	45	17,000	52	12,000
Nitrogen, total organic + ammonia[b]	mg/L	lbs/day	0.10	0.47	28	2.0	740	1.3	300
Ammonia, dissolved, as N[c]	mg/L	lbs/day	0.040	<0.040	<2.4	<0.040	<15	<0.040	<9.3
Nitrogen, nitrite, dissolved, as N[c]	mg/L	lbs/day	0.008	<0.008	<0.5	<0.008	<3	<0.008	<2
Nitrate + nitrite, dissolved, as N[c]	mg/L	lbs/day	0.050	e0.032	e1.9	<0.050	<19	<0.050	<12
Total nitrogen, as N[d]	mg/L	lbs/day	na	e0.50	e30	<2.0	<740	<1.4	<320
Organic nitrogen, as N[e]	mg/L	lbs/day	na	≤0.47	≤28	≤2.0	≤740	≤1.3	≤300
Total phosphorus, as P	mg/L	lbs/day	0.060	0.082	4.9	0.345	130	0.285	66
Dissolved phosphorous, as P	mg/L	lbs/day	0.060	<0.060	< 3.6	<0.060	<22	<0.060	<14
Total cadmium	µg/L	lbs/day	0.04	0.19	0.011	0.10	0.037	0.08	0.02
Total copper	µg/L	lbs/day	0.6	19.4	1.2	20.3	7.6	17.5	4.1
Total lead	µg/L	lbs/day	1	6	0.4	3	1	3	0.7
Total zinc	µg/L	lbs/day	1	93	5.5	42	16	33	7.7

[a] Minimum reporting levels are based on values published by the USGS National Water Quality Laboratory.

[b] Nitrogen, total organic + ammonia is total Kjeldahl nitrogen.

[c] Ammonia, nitrite, and nitrate + nitrite are analyzed from filtrate. In January 1993, USGS National Water Quality Laboratory analyses for total ammonia, total nitrite, and total nitrate + nitrite were discontinued and only dissolved ammonia, dissolved nitrite, and dissolved nitrate + nitrite were analyzed after that date. Values for the total and for the dissolved constituents were statistically indistinguishable (U.S. Geological Survey Office of Water Quality Technical Memorandum 93.04). USGS National Water Quality Laboratory methods for these constituents are different from USEPA methods; however, USGS methods have similar or more accurate results.

[d] Total nitrogen is calculated by adding nitrogen, total organic + ammonia (Kjeldahl) to nitrate + nitrite, dissolved. If the concentration value of nitrate + nitrite, dissolved is below the minimum reporting level, the concentration value of total nitrogen is reported as less than the sum of the values shown for nitrogen, total organic + ammonia and nitrate + nitrite, dissolved, which represents the maximum possible value for total nitrogen. If the concentration value of nitrate + nitrite, dissolved is estimated and below the minimum reporting level, the concentration value of total nitrogen is reported as the sum of the values shown for nitrogen, total organic + ammonia and nitrate + nitrite, dissolved, and noted as estimated.

[e] Organic nitrogen is calculated by subtracting ammonia, dissolved, from nitrogen, total organic + ammonia (Kjeldahl). If the concentration value of ammonia, dissolved is below the minimum reporting level, the concentration value for organic nitrogen is reported as less than or equal to the value of total organic + ammonia (Kjeldahl), which represents the maximum possible value for organic nitrogen.

[f] Average load is computed from the concentration value and the average discharge during sample collection.

APPENDIX: DISCHARGE REPORTING AND LOAD CALCULATION METHODS

This appendix further defines the methods used for reporting discharge data and for the calculation of constituent loads. Data is seldom exact. In order to adequately qualify the quality of discharge and water-quality data, values are rounded off to the number of significant figures that best describes the precision of the measurement.

Discharge data.--Table 29 shows the number of significant figures and rounding limits for the range of discharges in this study. Measurements made using meters or float measurement techniques, discharge determined by stage-discharge relations, and average discharge values for composite samples are reported using these guidelines.

Calculation of loads.--Table 30 shows the conversion factors used for determining constituent loads. Constituent loads for all analyses except for fecal coliform are reported as pounds per day (lbs/day) and are calculated by multiplying the concentration value, in either milligrams per liter (mg/L), or micrograms per liter (µg/L), by the discharge value, in cubic feet per second (ft^3/s) and the appropriate conversion factor. For fecal coliform, the concentration unit is most probable number of colonies per 100 milliliters (MPN/100mL), and the load unit is billion colonies per day. Four significant figures are used for the conversion factors, however, the load value is reported with the lesser number of significant figures of the values of concentration and discharge.

Table 29. Significant figures and rounding limits for discharge measurements.
[ft^3/s, cubic feet per second]

Range of discharge (ft^3/s)	Significant figures	Rounding limits
< 0.10	1	hundredths
0.10 to 0.99	2	hundredths
1.0 to 9.9	2	tenths
10 to 99	2	units
>= 100	3	variable

Table 30. Conversion factors for converting constituent concentration and discharge data to daily loads
[mg/L, milligrams per liter; µg/L, micrograms per liter; loads; MPN/100 mL, most probable number (of colonies) per 100 milliliters; lbs/day, pounds per day]

Unit of concentration	Conversion factor	Load unit
mg/L	5.394	lbs/day
µg/L	0.005394	lbs/day
MPN/100 ml	0.02447	billion colonies per day